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THE SCIENCE OF PSYCHOLOGY

THE SCIENCE OF PSYCHOLOGY

AN INTRODUCTORY STUDY

BY

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TO

THE MEMORY OF

JOHN WALLACE BAIRD

PREFACE

Progress in science is marked by a continuous refinement of method, with a resulting increase in accuracy of data. Generally, methods are at first simple and crude, and as advances are made, a greater amount of technical knowledge is required, not only for a conception of proper methods but for an understanding of the results. Nevertheless, the cruder methods and indefinite results obtained from them, together with the working hypotheses that led to their use, serve as convenient and fruitful points of departure for the student. His common sense knowledge is often sufficient to give him an understanding of the cruder and more general facts. With less effort than is required to assimilate at once a mass of technical and abstracted details, and consequently with less danger of becoming discouraged, he thus gains an insight into the problems of his science. At the same time the outstanding ideal of science always to improve upon the existing body of facts by the employment of better technique is forcibly brought to his attention as he learns about the later and more accurate methods and results. For these reasons the author has drawn generously in each chapter from the history of psychology, and for the same reasons he has presented, first in the text, facts and theories of a simpler and more general character.

In the author's judgment the newer psychological texts have for the most part erred on the side of too great simplicity and brevity. Students often complete a semester or even a year of psychology without a real introduction to the subject and with almost no conception of psychology as a science. Progress in text-book writing has not kept pace with psychological research. Moreover, the science is being devitalized by an adherence to old problems and theories, and in some instances by an adherence to obsolete data. This

condition is to be expected while a science is undergoing radical changes in standpoints and methods. In fact, the overabundance of new psychological texts seems clearly to be an expression of groping, a realization of inadequate standards.

The present attempt does not claim to satisfy adequately the need of improving the status of the science, but it finds in principles hitherto not emphasized in American psychological texts, a means of reorganizing the facts of psychology in a way that may assist in removing the difficulties just mentioned. These principles have been taken from *Gestalt* psychology and from independent developments in physics, neurology, physiology and sociology. The text makes no distinction between the subjective and objective points of view as such, and stresses no dichotomy between existential and empirical psychology. It aims at a presentation free from philosophical presuppositions. It brings the facts of behavior under the law of least action and its corollaries, the principle that the whole determines the functioning of its parts and the principle that action, including behavior, is directed by a remote end which is established before action begins.

Accordingly, the organization of the book claims an expediency of a logical as well as a pedagogical character. In fact the pedagogical advantage that accrues from it hinges upon the logic of its arrangement. The facts that are naturally and logically primary in any system should be the easiest and simplest to grasp. If the principles applied throughout the text are valid, the whole is genetically and logically prior to its parts. With these considerations in mind, instead of beginning with sensations and reflexes and ascribing to them the conventional systematic meanings, the book commences with the whole of which the human being psychologically is a part, namely, the social group. Social, as well as other modes of behavior, are explained in terms of configurational (organismic) principles. The later chapters are devoted to sensation and the nervous system. The text reverses the customary order of subject matter because it adheres throughout to principles in many respects the opposite of those around

which previous systems have been written. A sincere effort has been made not to show a disregard for previous and contemporary psychologies of other types. If configurational principles and methods are emphasized to the neglect of other and useful procedures and hypotheses, it is from lack of space and merely for the purpose of presenting the newer point of view in as great a clarity of detail as possible. An attempt has been made to cover a wide range of facts from psychologies of all types and vintages and to interpret them in the light of a particular set of principles.

It would be impossible to mention all of the sources of influence to which the author is indebted, but special mention is due Dr. Harry Helson, a former colleague, whose use of the law of least action and whose sympathy for many other configurational principles greatly increased the author's interest in them. Further acknowledgment is due him for his encouragement and for many stimulating and kindly criticisms of the manuscript. Other colleagues, past and present, who have given valuable aid are Dr. J. P. Guilford, whose suggestions were most helpful, Drs. Beulah M. Morrison, Harry R. DeSilva and Paul C. Squires, who rendered constant and unstinted assistance throughout the preparation of the manuscript. The author owes a debt of gratitude to Prof. Seba Eldridge, who offered many valuable comments, and especially to Prof. R. M. Ogden for his interest and criticisms in reading the manuscript before it went to press. None of these colleagues is in any way responsible for features of the book which may prove to be undesirable. Generous aid was given also by Mr. Edwin B. Newman, who helped in many capacities throughout the preparation of the book, and by Mr. Howell Lewis; also by Mr. F. Theodore Perkins, whose untiring help immeasurably lightened the burdens of recasting the manuscript and preparing the figures. Thanks are also due Mrs. O. B. Baldwin for help in making the figures, and especially to Mr. S. Howard Bartley, who gave plentifully of his time in drawing many of the figures. To Mrs. Beryl Warden and Mrs. W. H. Horr thanks are due for their work in typing the manuscipt. Last but not least is the encouragement and

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In dedicating this book to the memory of John Wallace Baird, teacher, friend and counsellor, the author acknowledges enduring gratitude to one whose confidence, affection and instruction made an indelible impression upon him.

RAYMOND H. WHEELER.

Lawrence, Kansas,
June, 1929.

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THE SCIENCE OF PSYCHOLOGY

CHAPTER I

INTRODUCTION

The Subject Matter of Psychology

Introduction. Human beings are constantly predicting the behavior of their associates. A man extends his hand in cordial greeting and expects his friend to reciprocate. A wife prepares dinner for six o'clock certain that her husband will return from his work. The lover sends flowers to his sweetheart in the belief that his thoughtfulness will please her. The hard working laborer deposits his savings in the bank trusting in the honesty of its officials; the merchant extends credit to his customers expecting them to pay their bills; the manufacturer foretells the needs and desires of the public in the commodities which he creates. Further illustrations could be multiplied indefinitely showing how on the one hand, everyone analyzes and predicts human behavior in a common sense fashion. On the other hand, the psychologist studies behavior *scientifically* for the purpose of making more exact predictions, and predictions of a greater variety than can be made merely from a common sense knowledge of human nature. The psychologist regards human nature as *behavior,* and in his investigation of this behavior he finds that its outstanding characteristic is its *conscious aspect.* He thinks of the human being, therefore, as a conscious organism.

Definition of General Psychology. Psychology deals with the behavior of conscious organisms. By a conscious organism we mean any animal or human being engaged in activities like seeing, hearing, thinking or feeling, and by behavior we mean any activity carried out by an organism-as-a-

whole in making adjustments to its environment. The psychologist is interested in describing and accounting for behavior, especially when it is conscious. To satisfy these interests he investigates the circumstances of its occurrence and once the circumstances are discovered he possesses facts which he considers to be explanatory. *Psychology, then, is a study of conscious behavior and of the conditions under which that behavior takes place.*

Definition of Human Psychology. Since we live in a world composed not only of physical objects but also of people, human behavior is distinctly social. In fact certain authorities believe that conscious behavior in man depends upon a social environment, and they define human psychology accordingly as the science of social behavior. It is obvious that human behavior occurring under natural and unrestricted conditions *is* social. Social behavior, however, is too complex for detailed study until its conditions have been limited, *first,* by selecting only a few controlling factors of a strictly social character and then observing the resulting behavior. Because of the restricted conditions the consequent activity will be a special kind of social behavior, for example the attitude of parents toward children, of one race toward another, or of an individual toward a great leader. In any case we are abstracting certain classes of events from social behavior at large. *Second,* we may choose conditions which disclose a behavior whose outstanding features are not social. Whatever these features are, the resulting behavior is defined and explained in terms of the limiting conditions. One set of conditions will define behavior as intelligent, and as we shall discover eventually, a more restricted set of conditions will define it as emotive, and so on. We can continue this process of narrowing down the conditions under which behavior takes place until we have isolated the relatively very simple events of seeing, hearing, tasting and feeling specific objects. If we limit the conditions of behavior still further we finally enter the field of physiology where, from the standpoint of the psychologist, nothing remains except bodily organs in which chemical and physical processes are occurring. We are ready to *define human psychology as the study, first, of social be-*

havior with its various limited and specialized activities, and second, of those forms of behavior which can be abstracted from it.

General Conditions of Conscious Behavior. There are certain general conditions under which conscious behavior occurs. *First,* the organism must be an intact, working unit; any injury or disease which destroys the unity of the organism results either in abnormal behavior or death. *Behavior, then, is the activity of an organism-as-a-whole.* What shall constitute a total organism, of course, varies within certain limits. For example, a man may lose both legs and still be a conscious, behaving organism. But there are certain systems of organs, among which is the nervous system, whose various parts can suffer only limited injury without incapacitation of the organism for any kind of conscious behavior. *Second,* the organism must be living in an environment which furnishes constant stimulation. By stimulation we mean the activating influences of physical forces or social situations upon the organism. Whatever the organism does as a result of this stimulation is called a *response,* and the specific mechanisms of response in man are the nervous system, muscles and glands. With these bodily structures the human being sees, hears, thinks, fears, loves, hates and carries out all forms of overt action such as locomotion, manipulation of objects, and talking. *Third,* from the time of its conception, the organism commences to grow and mature in certain definite directions which are laid down in the history of the species or race. The history of the species or race, which we call its *phylogeny,* is therefore a remote condition of behavior.

Sources of Psychological Data. It is an error to conceive of any one science as an isolated, compartmentalized body of facts. Chemistry, for instance, involves a study of physics, and psychology is a *biological* science from the standpoint of the *individual.* If one is interested in explaining the bodily mechanisms underlying human behavior one must seek their causes in physical, chemical and physiological facts. If this is the interest of the psychologist he must study the human being not as a member of society but as an isolated

organism. Moreover, under these circumstances, in order to ascertain the laws of behavior he must carefully isolate and control its various aspects one by one; this is the function of the laboratory. To anticipate a few typical problems of *individual* psychology: What are the bodily structures responsible for seeing, hearing, feeling, experiencing emotions, remembering, learning and thinking? What are the conditions under which these bodily structures operate or fail to operate? What are the descriptive criteria of the activities just mentioned? From the standpoint of individual psychology how are these activities to be identified? What are the methods by which they can be isolated, measured and controlled?

Facts obtained from a study of isolated individuals do not furnish a complete picture of the human being, nor do they make it possible to predict and control more than a small amount of his actual behavior. Many of the factors which ordinarily govern his reactions are eliminated by segregating the individual for the purpose of specialized study; these factors inhere in his social environment. When for convenience the conditions of his behavior are limited by taking him into the laboratory *the resulting facts are significant only with respect to the limiting conditions.* Man should be studied, therefore, not only as a biological organism but also as a member of society. Then it becomes evident that seeing, hearing, remembering, thinking, 'expressing' emotions, indeed all modes of behavior, are social as well as biological in their character. Among the many social situations which control behavior are the family, a host of social organizations, the crowd, national customs and traditions, religion, stratifications of society, public opinion, laws and forms of government. Both the individual and society are the sources of psychological information, but the student should not conclude that there are two kinds of psychology, individual and social. In the last analysis there is only one kind of psychology, one set of principles applicable to the behavior of conscious organisms, although there are various fields in which these principles apply and each field has its own unique and particular problems. These fields include animal, child, abnormal, individual and social psychology.

Values of Psychology

(1) The Mediocre Character of our Actions Shown by Psychology. There is no complex instrument used by man with so little regard for its efficiency, or with so meager a knowledge of its laws of operation, as his own system of nerves and muscles. There are varied reasons for this curious state of affairs. *First,* among them is the fact that psychology is relatively a new science; it is just beginning to discover the fundamental laws of behavior. *Second,* the average man is satisfied with a mediocre execution of his tasks. How many are there who play golf or tennis, or engage in any form of recreation involving skill, who take pains to master the game, though they may have ample opportunity? How many are there who make a serious effort to become expert even in the use of their own language? Performances of commonplace and menial tasks like washing dishes, sweeping floors, shoveling coal, raking hay, husking corn, and, in the trades, setting type, laying bricks, handling machinery, and so on, are often unnecessarily expensive in time and energy. Studies made with the slow moving picture camera, supplemented by scientific analyses of the minimum necessary movements, show an almost unbelievable amount of waste motion. *Third,* there are many persons who are afraid of thinking too much! To think may be strenuous but no more disastrous than steady and vigorous physical labor. Yet man avoids thinking whenever an easier method of handling a situation presents itself; he must either be highly motivated or in a crisis in order to think his best. A knowledge of the laws of learning and thinking would go far in bringing him to a realization of his inefficiency.

(2) Unreliability of Memory. Remembrances of past events are proverbially inaccurate. Psychology reveals the reasons for this fact and informs us how to minimize errors of recall. To begin with, most persons are poor observers; they see and hear inaccurately. Moreover, there are numerous attitudes and motives which lead them to overlook certain details of the world about them and to overemphasize other

details. These same attitudes and motives work additional havoc whenever attempts are made to relate past experiences.

(3) Vocational Applications. Psychology has many vocational uses. For example, in industry an untold amount of waste has occurred because of attempts on the part of employers to fit men to jobs rather than jobs to men. The labor turnover, great as it normally is, especially among unskilled workers, is greater than is necessary because of hasty selection of men without regard for their aptitudes. Then, in the vast business of advertising, many applications have been made of psychological principles in the arrangement of material within the advertisement and in the selection of themes which will attract the attention of the reader.

(4) Psychology and Medicine. Psychology has a wide application to medicine. Every physician knows the psychological advantages to be gained by administering sugar coated pills, and recognizes the tremendous rôle that mental attitudes play both in the exaggeration of illness and in the facilitation of recovery. A subsequent study of suggestion and emotion will make plain the very close relationship that exists between psychology and medicine.

(5) Psychology and Education. Psychology finds its widest application of all in education, for mental development is a function of environmental as well as of phylogenetic factors. For example, feeblemindedness can be produced by extreme neglect of the child. On the other hand, marked precocity can be induced by sufficiently intensive and persistent training of the normal child. This condition, however, is often induced at the expense of health and of proper social adjustment in later life.

We attempt to direct the mental development of the children of the nation, between the extremes of feeblemindedness and precocity, by a system of education a certain amount of which is compulsory. Whether our educational system will do what we aim to have it do depends on the extent to which we understand and apply psychological principles, for the laws of mental growth are psychological laws. Upon the adequacy of our psychological knowledge depends the optimum rate at which we should encourage children to develop, the extent to

which we can make education fit the needs and types of pupils, and the extent to which they will profit in later years by their earlier education.

(6) Socialization of the Individual. The educative process requires eight to sixteen years and over this long period of time when the individual is being molded, in some respects for life, much can be done either to harm or to help him. Not of least importance during this long interval is the *socialization of the individual,* by which is meant developing in him such attitudes toward other persons, social groups, races, and his own and other governments as will make him a useful, constructive and efficient social being.

(7) Mental Hygiene. It is as easy to distort the personality of an individual as it is to retard or accelerate his intellectual growth. The development of personality follows certain definite laws. If discipline is not temperate, or if the social environment is unhealthful, the child's personality is sure to be affected. A stable personality rests also upon a proper balance of likes and dislikes, upon an appropriate satisfaction of natural impulses and upon a sane interpretation of social and economic values by those who educate the child. Psychology has much to say concerning ways and means of safeguarding the development of character. This phase of the science is known as mental hygiene.

(8) Leadership and Knowledge of Human Nature: a Social Application. The social order in which we live is guided in large measure by a small group of individuals upon whose intelligence and leadership the behavior and the welfare of the masses depend. These leaders mold public opinion and determine our ways of living by giving to society scientific inventions; they initiate and change fads and customs, make laws, establish moral codes and work out for us an articulate expression of our entire philosophy of life. The leader, therefore, owes to society the obligation of understanding human nature as thoroughly as possible in order that through his leadership he may apply superior knowledge in his control of the group.

(9) The Study of Psychology for Its Own Sake. Finally, for some individuals a study of human nature is not

only a means to an end but a goal in itself. It is an art to be pursued for the sheer pleasure which it affords. Such is the motive which prompts the psychologist or any scientist to devote his whole life to problems many of which confine him to the laboratory or to the clinic for months at a time. Numerous are the scientific problems, no matter what the field may be, which resist solution and require years of patient, careful and self-sacrificing endeavor.

The Scientific Method

The Scientific Attitude. Students who have not acquired a scientific attitude before they become of college age will not find this attitude easy of attainment during the brief exposure furnished by a beginning course in psychology. Yet for an adequate grasp of the spirit, purpose, method and facts of psychology, the acquisition of such an attitude is essential. *First,* a scientific investigator should approach his subject matter with an open and unprejudiced mind but at the same time in the spirit of questioning, criticism and doubt. Facts and theories, alike, should not be accepted merely on the basis of authority without an independent attempt to ascertain their reasonableness. *Second,* an investigator should be persevering. Many are the problems which will require prolonged concentration on his part, with patience and devotion to his task. *Third,* an investigator should exercise all the caution and precision in his technique and thinking which he has at his command. He should not come to conclusions hastily or be certain of his facts until they have been carefully verified. The student of science is an amateur investigator, and his attitude should be that of an investigator! He is otherwise wasting his time.

The Purpose of Science. The ultimate purpose of science is the prediction and control of events. In psychology it is the prediction and control of conscious behavior. This purpose is achieved by subjecting the behaving organism either to controlled conditions in the laboratory or to repeated observations under constant conditions in everyday life. When an investigator fails to

keep his conditions controlled during the period of observation, results are certain to be unreliable. If he fails to keep them constant from one observation to the next his results are again unreliable. It is the purpose of experimentation to keep these conditions as constant as possible while the observer makes an abundant series of observations.

The Purpose of Definitions. The student of science should not only maintain the attitude of the truly scientific investigator, and always keep before him the purpose of science, but he should also safeguard his use of definitions. The purpose of definitions in science is very frequently misunderstood. It is the popular belief that they are absolutely true statements and that when once formulated they will always be true. Accordingly, a definition is often regarded as a declaration to be accepted on faith, uncritically. On the contrary, definitions in any science are always subject to change as knowledge accumulates. Indeed, they are never considered final statements of fact; they are like working hypotheses. They are condensed and convenient statements about different types of objects, occurrences or situations, which the scientist accepts for the time being. Their purpose *first,* is to help him summarize his knowledge, and *second,* to give him reliable concepts for use in organizing that knowledge. *Third,* they serve the purpose of simplifying his thinking, since they symbolize the results of a great many observations. *Fourth,* they clarify his thinking and facilitate agreement and common understanding among those who talk in the language of science. *Fifth,* they aid in understanding newly discovered facts because they constitute a body of information to which the new discoveries can be related. It is precisely this discovery of new facts that so often compels the scientist to change his definitions.

The danger of placing too great a reliance upon definitions should now be obvious. If the scientist regards them as absolute statements of the truth they may lead him to misinterpret the significance of new discoveries,

and hamper his thinking by giving him too restricted a conception of the facts. These considerations have prompted many scientists to argue that a truly careful statement of the facts should not begin with an array of definitions. Rather, the results of observation should come first, and definitions last.

The Value of Theories. In science, theories share the importance that is often attributed to facts alone. Persons who are interested only in facts are likely to regard theories as impractical, but in doing so they overlook the purpose for which theories are formulated. Theories, like definitions, are working hypotheses. They stimulate thinking, raise problems and issues, and lead to new discoveries. Facts, with no theories behind them, with no way of organizing and relating them, would lead to nothing new. Under these circumstances progress in science would be impossible. The very facts which the layman considers practical—facts leading to the invention of the electric light, the telephone, the steam engine, the automobile—were discovered only after theories had been formulated and numerous attempts had been made to prove or disprove them.

The Relation of Working Hypotheses to Experimentation. Every scientific experiment commences with a working hypothesis which is to be thoroughly tested. The hypothesis should be tentative, however, because a prejudice or a preconceived notion on the part of the observer may produce mistakes in results, or at least wrong interpretations. For example, a common error occurs in apprehending more meaning in the results of experiment than is actually present. This error is particularly prevalent in making observations on children and animals. To illustrate, an observer may see a dog with a bone in its mouth approach a hole in a picket fence, and to get through, turn its head until the bone is parallel with the pickets. To assert that the dog performed an intelligent act is to exceed the facts of observation, for the animal's success *might* have been accidental. That the act was intelligent is an hypothesis which should be tested by put-

ting the dog through a great variety of simple, puzzling situations.

Scientific Measurement. Scientific prediction involves not only stating in advance *that* a certain event will take place, but also stating *when* it will occur, *how long* it will last, and if possible *how much* energy it will involve. In other words, a prediction includes *measurement.* Accordingly, the facts of observation are ideally summarized in the form of mathematical equations. In the more exact sciences, like astronomy, physics and chemistry, most of the facts can be expressed in this way; but in psychology the events that are studied are often too complex and variable for mathematical expression. On the other hand, the science of psychology aims to refine its methods until definite measurements are possible.

Measurement in Psychology. The mental test has proved to be a rough but useful instrument of measurement in psychology. It indicates the relative position of an individual in the group with respect to a selected kind of behavior. It informs us whether or not he exhibits *more* or *less* of that behavior as compared with other individuals. More specifically, it locates the position of the individual with respect to the *average* of the group.

There are ways of standardizing the mental test statistically until it can be regarded as a rough substitute for the finer instruments of precision employed in other sciences. This standardizing is done in psychology whenever the events can not be observed directly and under rigidly controlled conditions. The test is an *indirect* method of observing an individual's behavior because it is not *necessary* for the investigator to see or hear the responses which constitute his data. Experimental investigations in the laboratory, however, depend largely upon direct observations of events. Here psychology does not altogether lack those instruments of precision and methods of treating results that make for exactness in the other sciences.

Functional Analysis. When the conditions under which behavior is observed are systematically varied and

the effects of these changes are noted, the procedure is called *functional analysis.* Suppose an investigator selects the problem of analyzing a learning process, say the learning of a poem; then he must determine what factors alter the learning when he varies them. He knows that certain of these conditions are as follows: *First,* the material possesses a certain degree of familiarity. *Second,* as the learner sets out to memorize the poem he assumes a definite attitude toward his task. He may be intensely interested, or he may be learning under compulsion. *Third,* he may adopt the procedure of memorizing the poem stanza by stanza, or he may attack the material as a whole at each reading. *Fourth,* he may attempt to learn the entire poem in one study period, or he may distribute his efforts over several periods. These are only a few of the conditions of learning each of which contributes to its explanation.

Whether or not familiarity with the material of the poem is a controlling factor can be tested by presenting the learner with relatively nonsense or strange material to memorize. The effect of his attitude can be determined within limits by providing incentives on the one hand or by ignoring them on the other. The influence of repetitions can be measured by scattering them over different intervals of time. If the learner makes as much progress with one repetition a day, as he does with ten a day in one continuous work period, it is obvious that repetitions are surbordinate in importance to the time intervals between them.

Functional analysis, then, is the procedure of varying the conditions under which a phenomenon occurs in order to ascertain what conditions are essential to its existence. Knowing that such and such a change in the conditions leads to such and such a change in the event we can control the event as we like, within certain limits of course, by controlling a number of its conditions. In the meantime the event as a whole is preserved. In our illustration we did not prevent the individual from learning the poem; we did not eliminate the learning process. There is another

kind of analysis, however, which is destructive of the phenomenon to be analyzed. It is called *structural analysis* because it reduces a unified whole to its parts, structures or separate aspects.

Structural Analysis. The physicist informs us that all objects are masses of electrons and protons. He defines these electrical phenomena as concentrations of energy. Objects, then, are active, dynamic things; they are not static and dead; they are after all activities, occurrences, events. For example, the anatomist studies the human body, dead from a biological standpoint but still an event from a physical standpoint; he dissects it to ascertain its gross and microscopic structure. This procedure is accomplished by destroying the object of analysis. The anatomist is so radically changing the conditions under which the body exists that he reduces it to *isolated* and *separated* structures. Likewise, the chemist may so alter the conditions under which a compound exists that he breaks it down to its so-called ingredients or elements; he disintegrates the compound and reduces a physical complex of motions to a simpler level, a simpler order of events. *Structural analysis, therefore, is any kind of analysis made when the conditions of investigation are so selected as to reduce the complexity of the object or event under consideration.* Roughly it is a reduction of a whole to its parts.

Structural and Functional Analysis Compared. When we regard events as things or objects and wish to *describe* them we find ourselves asking the questions: How are they constituted? How are they to be recognized? How are they to be classified? All these have to do with structural analysis. On the other hand when we want to know what happens to events when we change their conditions without changing their basic character we are answering such questions as these: How are we to *explain* them? Why did they occur? What accounts for the existence of these events that are known as objects? Here we are dealing with functional analysis. To make a functional analysis of the human being is to study his activities without destroying him. For example, the physiologist makes functional analyses of specialized organs of the body when he studies digestion, breathing, metabolism and the

like, without destroying the organs in question. The psychologist makes functional analyses of the human subject as an intact, unified whole, by changing the conditions of the subject's behavior. Then he observes how that behavior is modified or controlled by the changed conditions.

The Psychologist's Procedure in Structural Analysis: Introspection. The psychologist makes structural analyses also. Remember that it is conscious behavior in which he is particularly interested. It is possible to abstract from any form of conscious behavior, such as a fear-reaction, those features which make it conscious. When abstracted from the original fear-reaction these features are called *mental processes.* Considered apart from the reaction as a whole they are known as the emotion of fear. Emotion is in itself so complex that it can in turn be analyzed structurally, that is, broken down to experiences of a 'lower' order than fear; these experiences are called *sensory processes.* Some of them may be recognized superficially by their popular names as a 'sinking feeling in the stomach,' 'cold chill,' 'dry mouth,' and 'choking sensation.'

Let us take another example. A very commonplace mode of human behavior is the recollection of a past incident. Suppose it to be a camping trip. You live over again the experiences you had at the time, and you find, by introspection, that your 'memory' involves talking to yourself and seeing 'in your mind's eye' the fir tree under which you spread your tent, the lake in front and the snow-capped peak beyond. Perhaps you seem to smell over again the odor of the evergreens, hear the sighing of the wind through the trees and the rippling of the waters against the sandy beach. Such processes as these are products of abstraction made by introspective, structural analysis. They are called *images.*

The Purpose of Introspection. The psychologist's procedure of abstracting from conscious behavior those features which give to it its conscious aspect, and of analyzing them, is called *introspection* or *self-observation.* It is a technique peculiar to psychology because psychology studies events which other scientists do not study, namely *conscious* behavior. This technique is roughly comparable to morphological or

anatomical analysis in biological science and to qualitative analysis in chemistry. The procedure is undertaken always for the purpose of isolating from very intricate human reactions certain aspects, features or parts for specialized study and control. This procedure helps in many ways to understand the character of the complex reaction with which we started, and to relate it to other reactions of like complexity; hence it aids in classifying the various modes of behavior. Moreover, introspection gives us the *conscious setting* in which behavior takes place, just as a knowledge of the human body furnishes us the *organic setting* in which physiological processes occur, and just as the study of sociology gives us the *social setting* in which specific acts of individuals take place in daily life. It is important to know about these settings because without them isolated events can not be understood in their relationships, and there is no information as to what events to isolate. It would be of slight value to know about the chemical processes of digestion which can be studied in a test tube, without understanding the organic setting in which digestion naturally takes place, namely, the stomach and intestines. Likewise a knowledge of human behavior is incomplete so long as there is no information available concerning such processes as thought and feeling.

Suppose an experimenter wishes to study the process of choosing. At the outset his own introspective analysis of choosing informs him of what constitutes a choice; and by this means he knows that choosing involves in its simplest form a balancing of motives for or against two alternatives. Hence he knows in a general way how to induce these processes in his subjects. If the experimenter's purpose is to control the motives for choosing he must first ascertain by introspection what these motives are. A superficial type of introspection leads to many functional problems of this character. But if the experimenter undertakes the solution of more refined and specialized problems, such as the determination of the sensory processes that are essential to choosing, his introspective data must be obtained by more refined analyses or else the processes to be brought under control are not known. In short, at each step in his investigation of any

kind of thinking, structural analysis is necessary in ascertaining what processes to vary by changing their conditions. Since changing the conditions of an event is an essential feature of functional analysis, this method of studying mental processes would be impossible without introspection.

The Whole-part Relationship. We said that structural analysis reduces a whole to its parts, while functional analysis preserves the whole. This statement introduces us to the problem, What is the relationship of a whole to its parts?

Scientists have sometimes assumed that the whole could be explained in terms of its parts, but this is not true because the *whole is more than the sum of its parts.* For example, water is more than hydrogen and oxygen for it interacts with other chemicals as neither hydrogen nor oxygen will. It has properties that neither the hydrogen nor the oxygen possesses. Similarly, the human being is something more than an aggregation of muscles, bones and nerves, as shown by the fact that the total organism exhibits a behavior which no one part is capable of exhibiting. Indeed, as we shall see later on, the organism-as-a-whole, any whole for that matter, determines to a considerable extent the behavior of its parts.

A whole *disappears* when we reduce it to its parts. We no longer have table-salt when we break it down to its ingredients which are sodium and chlorine. We no longer have a human being when by accident, maltreatment or death, its unity is destroyed. We no longer have an experience like fear when by introspection we analyze it into its sensory processes. In all of these illustrations we face the same ultimate question: What constitutes the difference between a whole and its parts? While we can not give an adequate answer, most writers on the subject agree that the whole exists in its own right and that the terms *organization* and *unity* describe the difference.

The person who holds that the whole can be explained by its parts or predicted from its parts is a *mechanist.* Science is abandoning mechanistic theories because they leave too many facts unexplained. A mechanistic theory will not account for the simple facts of gravitation; a falling stone is not pushed along its path by another small and isolated part of

the universe bumping against it from behind. *In order to understand gravitation a total system of stresses and strains must be taken into account.* The system is a unit which obeys its own laws; figuratively speaking, 'it runs itself.' As a system it governs the activities of its parts. Similarly all events in nature take place 'of their own accord.' If they were mechanistic in their character they would not occur of their own accord. A machine, like an automobile, which is an aggregation of parts and not a completely unified and organized system of forces, will not run of its own accord; *it will not direct the action of its parts.* A guiding hand is necessary to start it and to drive it.

It should be remembered that exact predictions of events in nature do not imply a mechanistic explanation. They assume exactness of knowledge and a knowledge that is ideally reducible to mathematical formulae. They mean that events exhibit law and order. Nothing, however, in the exactness of scientific knowledge prohibits a person from believing that the so-called physical universe is the actual functioning of an intelligence! It is a far cry, in other words, from precision in scientific predictions, to the assumption that the world, or any part of it, runs according to a blind, mechanistic principle, like a huge machine.

We shall have occasion, shortly, to minimize the scientific importance of a tradition that the human being is partly a material object and partly a mental or psychic object. This view assumes that physically he is a machine but that mentally he is not. Those who have held to this distinction between the mind and the body have never been able satisfactorily to explain the relationship between the two for the simple reason that the distinction itself is contradictory. How can an 'immaterial' mind that does not operate according to mechanical law function through a 'material' body which supposedly does function according to mechanical law? A much simpler and preferable view is the position that *natural laws are not mechanical.* We shall not then be committed to a mechanistic view of the human being for we have made no assumptions about his ultimate nature.

Now the human being as a unified, organized whole, ex-

hibits such activities as seeing, feeling and thinking. It makes no difference whether or not we call these activities mental. As scientists we are not interested in the question whether these are activities of a mind. It is sufficient to know that they are activities of the human organism, as a whole, intact being, a being which can not be explained in terms of dissected parts.

Sketch of the History of Psychology

Origin and Solution of the Perplexing Mind-body Problem. A thorough understanding of the problems and facts of present day psychology would be impossible without such a perspective as is furnished by a glimpse of the stages through which the science has passed. In ancient Greek philosophy (500–300 years B.C.) a problem appeared in its first stage of formulation, which was to command a prominent place in the thinking of philosophers and psychologists through the centuries, namely, the mind-body problem. Insofar as there was at that time any psychology it was regarded as the study of the soul. In fact the term psychology comes from two Greek words, *psyche,* soul, and *logos,* doctrine. Certain aspects of this soul, originally assumed to be reason and will, were regarded as immortal, while other aspects, like sense-perception (seeing, hearing, tasting) were known to be dependent upon bodily functions, and were said to perish with the body. Such a problem as the relation of mind and body was bound, therefore, to be associated with religious and philosophical questions. Centuries later, Descartes (1596–1650) attempted to explain physical phenomena by positing the existence of a material substance, *matter,* which occupied all space, and to explain mental phenomena by positing an immaterial substance, *mind,* which did not occupy space. Then logical difficulties arose in trying to conceive of a relationship between these two alleged entities. How, for example, could an immaterial substance act upon a material substance? It remained for certain contemporary philosophies and for science to reduce the confusion by *questioning both the hypotheses of matter and of mind.*

Meanwhile, what was originally academic philosophy, namely, the distinction between mind and matter, has been handed down from generation to generation not only as common sense but as proven fact. That is why the average person is at once confounded when he learns that, after all, the notions of the physical world as a material one (made of matter) and of mind as something immaterial (not made of matter) are philosophical speculations. Strange as it may seem the physicist has not found matter and the psychologist has not found mind. *Instead, both groups of scientists have been discovering different sorts of events that are reducible in a last analysis to a common set of laws.* The ultimate nature of all these events is unknown and is a problem for philosophy and religion, not science. The problem of the relationship between 'mind' and 'body' is irrelevant to the purpose of analyzing and controlling human behavior.

For convenience we still call feeling, emotions, thinking, seeing, hearing and the like, mental, but merely in order to give these activities a group name just as we classify the facts of anatomy and physiology as biological facts and other sets of facts as chemical, geological and economic. It must be remembered, then, that when we speak of mental processes we are not implying the existence of a metaphysical ultimate, a consciousness, or a mind, which must be contrasted with matter. Where it is convenient to describe behavior in terms of muscles and nerves we shall do so. Where it is convenient to describe it in terms of feeling, emotions, thinking, and sensory processes we shall not hesitate to use these terms. In any event we are accepting behavior just as we find it without assuming a mind-matter or mind-body problem.

Faculty Psychology and Its Influence. Other notions originated vary early which still play important rôles in our psychological thinking. One of these was the notion that 'mind' could be reduced to 'faculties' or elements. In ancient times mind was thought to be composed of two faculties, intelligence and will, which manifested themselves in various ways. Later a third was added, feeling. Before this tendency to divide mind into fixed elements declined, it became popular to define memory, attention, reasoning, and any other

mode of behavior which happened to be observed and could not be analyzed, as distinct and separate faculties each of which was supposed to reside in a certain compartment of the brain.

Thus, Gall in 1804, and Spurzheim in 1832, published treatises on 'phrenology,' or the so-called science of cranial measurement. Their claims, while almost wholly false, had the wholesome effect of motivating a long line of very careful studies by anatomists and physiologists on the part played in behavior by different sections or areas of the central nervous system. In spite of the fact that these studies, which were made between 1840 and 1870, definitely exposed the fallacies of phrenology, there are many people today who believe that a bump somewhere on the cranium means a well developed faculty of mind housed in the region beneath, or that a dent means the lack of a certain 'power of mind.' Needless to say, the bumps and indentations are nothing more than thick and thin places in the skull.

Meanwhile the tradition of looking for faculties has persisted in the form of a search either for mental elements or for elemental bodily movements (reflexes). Yet, as we shall see later on, neither the hypothesis of faculties nor of mental and reflex elements was justified by facts of observation. Moreover, our present day inclination to speak of mental abilities or capacities is but another variety of this same heritage from faculty psychology.

Problems Faced by the First Experimental Psychologists. The experimentalists inherited the idea that psychology was the science of consciousness. In order to explain the so-called facts of consciousness they could choose between four fundamental, historical principles or concepts which had evolved through the centuries, namely, *association, attention, will,* and *memory.* On the other hand, they could absorb them all, and this is what they actually proceeded to do. They took over the theory that we learn by *associating* one experience with another. Learning, mental growth, and creative imagination, therefore, were *dependent wholly upon association.* Likewise, recalling anything was *based upon memory.* Making one observation instead of another at any particular time

was *caused by attention;* in other words, attention determined whatever object or thought was held in 'consciousness' at any given moment. And finally, deciding upon a certain course of action was a product of the *will.*

Only in relatively recent times have these four alleged 'mechanisms of consciousness' been discarded as causal agencies, but attention and association have been retained in contemporary psychology as concepts that are necessary in order to give a complete account of mental life. Such a necessity, however, too often hinges upon the belief that unique principles are demanded in accounting for mental processes, because the latter, it is said, are fundamentally different in character from physical processes. Whatever facts were to be discovered about conscious behavior were destined at first, therefore, to be systematized, organized and explained in terms of this quartet of alleged basic mechanisms of mind, the products of centuries of concentrated and heated speculation, little of which was tangible and factual. And it was the mind-body problem that was responsible for it all.

Origin of Experimental Psychology. Physics, chemistry, biology and physiology preceded psychology in breaking away from the traditions of philosophy. This fact, perhaps, explains why psychology owes its origin as an experimental science to problems which arose in laboratories already established in the other sciences.

About 1670, Newton encountered several difficulties in his research on light which he could not solve by any physical means known at that time. One of these pertained to color mixture. When colored discs were rapidly whirled in a color top the simultaneous stimulation of the same area of the retina by two or more colors resulted in a cancellation, if the colors were complementaries, and in a new color if they were not complementaries. There were also problems of contrast, adaptation, and certain visual after-effects which, like the problem of color mixture, seemed to belong to a different category from those physical problems that dealt with phenomena of light external to the retina.

At the Greenwich observatory, in 1796, a young assistant reported with apparent inaccuracy movements of stars across

the field of a telescope. He insisted that he was honestly doing his best; nevertheless, he lost his position. A storm of discussion developed over the causes for these and other discrepancies noticed in the time-observations made by different observers. Several years later it was ascertained that people differ within certain limits in the *quickness with which they can react to a stimulus.* The apprentice in the Greenwich observatory waited until a star was at a certain line in the field of the telescope, then looked at a nearby clock and recorded the time. He was slower in reacting than his master. The problem was finally recognized as a psychological one, and for many years it was called the problem of the 'personal equation.'

In the physiological laboratory, about 1840, Weber discovered a curious fact while experimenting on the sensitivity of the skin. While using two compass points he noted that when these points were no more than two millimeters apart he could shut his eyes and feel them as two on the tips of his fingers; but when applied to his arm he was obliged to move the points thirty to forty millimeters apart before he could feel them distinctly as two. On the thigh a distance of nearly seventy millimeters was required. Here was a problem which physiology hardly seemed able to solve for it was a problem in the psychology of space perception.

About 1860, Helmholtz, along with others, undertook a thoroughgoing study of a variety of such problems as have just been mentioned. Among his contributions was the founding of *optometry.* A young student who worked with him for a time, Wilhelm Wundt, later established a laboratory of his own at Leipzig (1879) in which he began to investigate reaction time, attention, space perception, feeling and emotion. This was the first psychological laboratory. Among Wundt's students can be counted the founders of American psychology and of many laboratories in Germany.

Recent Developments in Psychology. From this time on, lines of development became numerous and growth was rapid. We can mention only certain important events that have stood out within the last fifteen years. *First,* almost simultaneously in this country and in Germany, a reaction

against traditional psychology sprang up. It was a two-fold reaction: (1) Against the philosophical heritage, still lingering on, that psychology was the science of consciousness. If consciousness as an entity is not observable why continue to harbor a notion that engages us in a myriad of fictitious issues such as the mind-body problem? (2) The method which experimental psychology had developed in order to study this so-called consciousness was introspection, a method decidedly limited in its fruitfulness; some thought it was entirely inadequate. Observers were not coming to an agreement regarding the fundamental facts of psychology. Anyway, their assumptions of association, attention, memory, will, and consciousness were objectionable and were not leading to noticeable progress.

In America, this type of revolt took the form of a mechanistic movement led by John B. Watson who refused to admit the scientific problems of *conscious* behavior. Because of this refusal, the movement was called *behavioristic.* This movement was an extreme swing of the pendulum in the opposite direction from that of traditional psychology, but it preserved the *conventional logic,* for all behavior, he thought, was to be described exclusively in such physiological terms as nerve impulse, reflex and glandular response. In other words, he accepted the conventional view that activities of specialized parts of the organism account for the behavior of the organism-as-a-whole. The German revolt was of an entirely different character. It assumed the subject matter of psychology to be the conscious behavior of organisms, but attacked the traditional attempts to explain complex activities in terms of the simple, and objected to an account of behavior in terms of the traditional principles of attention, association, will and memory. This movement is known as *Gestalt* or *configurational* psychology, of which we shall have much to say.

Freud's concerted attack upon problems of the emotional life of human beings was the *second* important event of recent years. Prior to Freud, investigations of feeling and emotion had resulted in little if any progress because the individual was being studied in artificial, laboratory situations. He and his followers pointed the way to a much better understanding

of human nature by analyzing the entire emotional situation including its social conditions.

The *third* important event was the development of social psychology which pointed out the impossibility of securing a complete picture of the behaving human being so long as the relationships between the individual and the group are overlooked. Practically throughout the entire history of psychology the individual as such had been studied and the social character of conscious behavior had been neglected.

In other words, traditional psychology overlooked the important principle stated on page 4 that the results of observation are significant only with respect to the particular types of conditions under which the observations are made. Consequently if social conditions are ruled out, as most of them are when behavior is studied in the laboratory, relatively little concrete information comes to light which is applicable in the prediction and control of behavior in everyday life. On the other hand, in laboratory experiments, principles are often discovered that have an important bearing upon social behavior.

In our study of the human being we shall accept him as we find him, a consciously behaving organism, capable within certain limits of genuine self-determination. We shall find him a seeing, hearing, thinking, feeling, habit forming, reasoning, willing, socialized individual; and *we shall discuss such demonstrable facts as lead best to the prediction and control of his behavior. Whatever methods give us these results and whatever points of view assist us in understanding these facts will be considered acceptable.*

We find the normal individual at all times functioning as a unit, a complete, integrated organism, any single activity of which is so complex and presents so many different aspects that the activity is at the same time social and individual, inherited and acquired, new and habitual, emotive and intelligent. There is no possibility of dividing the subject matter of psychology logically into categories like social, animal, abnormal and individual, or into chapters on perception, learning, attention, memory, emotion and thought without arbitrarily abstracting from any and all activities of the organism

those characteristics of behavior which are not separated in nature. Hence in order to reduce these abstractions to a minimum we shall divide the subject matter according to methods which yield results of graded uniformity and precision. We shall begin with the cruder but none the less valuable methods, and discuss the results thus obtained; we shall then conclude with the more refined methods and the results which they yield.

The type of behavior that we shall study in the next few chapters is highly variable and subject to the influence of innumerable conditions. Predictions are, therefore, relatively difficult and inexact owing to the impossibility at the present time of bringing a sufficient number of these conditions under control. Nevertheless exactly the same spirit of inquiry, the same scientific attitude and in general the same principles will be found to apply as apply in the more exact sciences.

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CHAPTER II

SOCIAL BEHAVIOR AND ITS CONDITIONS

Social Factors Conditioning Individual Behavior

Purpose of the Chapter. The social aspects of behavior are the first facts to ascertain before isolating the human being from the group for the purpose of more specialized study. Eventually we shall make these abstractions in order to study the human being from the individual as well as from the social standpoint. But first we should learn something about him in his natural and unrestricted environment. The present task, therefore, is to study the social conditions of his behavior and their effect upon him. This means that for the time being the social group will figure prominently in our discussion of the individual. While we shall not concern ourselves with problems dealing specifically with groups, the behavior of the group can not be neglected as a conditioning factor in the behavior of the individual because no individual behaves independently of the group in which he lives. It is this influence of the group over the individual that finds emphasis in the following pages.

The Social Character of Behavior the Most Obvious of Its Aspects. Considering a human being under natural life conditions, What is the most obvious feature of his behavior? He awakes in the morning in a fashionable bed; he dresses in clothes determined by custom; he reads the morning newspaper in order to imbibe the latest opinion on current topics; he eats his breakfast with manners of which society approves, and he goes to his office where throughout the day he earns his living by ministering to the wants of others. Late in the afternoon he participates in a game of golf and at seven, in evening clothes, he dines with a group of friends

with whom he discusses business, politics and baseball. It is evident from this account that the most obvious fact about his behavior in general *is its social character.* Indeed, it is both fruitless and impossible to imagine what a human being would be like if from birth he were isolated from all individuals of his kind, or from any animal capable of rearing him.

The Individual Defined in Terms of the Group. The human organism is ushered into society at the very beginning of his life and consequently he commences *at once* to become a social being. This commonplace fact is the basis of an important principle, namely, that *an individual can not be defined adequately in terms of himself alone.* This, in turn, is but a single case of a much more comprehensive principle in science, that no object is defined adequately in terms of itself. Every object must be defined in part, at least, in terms of its relationships to other objects, that is, *in terms of the conditions under which it exists.* Since a social environment is one of the chief conditions of a human being's existence, he must be defined partly in terms of the social group in which he lives. Therefore, to think of him ultimately as an individual instead of as a member-of-a-group makes a complete account of him and his behavior logically impossible. Conversely, of course, the social group is not something apart from individuals.

How Human Nature Is Acquired. It is in the group that human nature develops. "Man does not have it (human nature) at birth; he can not acquire it except through fellowship, and it decays in isolation." [1]

This is because personality in others develops personality in the individual; the feelings and attitudes of others produce feelings and attitudes in him. So too, in the group to which he belongs man acquires his notion of himself as an individual. He learns to consider the needs of others as well as his own, and to accept group ideals, customs and standards of living, which become his own. He assimilates the group attitude toward outside individuals and other groups; consequently unless he rises above the intellectual level of his associates, he

[1] Cooley, C. H., *Social Organization.* New York: Scribner, 1909, 30.

regards outside groups with dislike if not with suspicion and fear. At least his attitude toward outsiders is one of indifference. *Indeed, there are no aspects of his personality that are not conditioned by the social group in which he lives.*

The Social Group as a Conditioning Factor in Man's Evolution. The social group seems to have been a conditioning factor in human behavior from the time the race began. Kunkel [2] insists that man evolved from his ape-like ancestors, not as an isolated individual, but as a member-of-a-group. This is a tacit recognition of the *group as an evolutionary unit.* Whatever may have been the causes of his first banding together, whether it was a selective process whereby those individuals who did not organize died in the struggle for existence, or whether it was an insight which enabled him to profit by the presence of others, the formation of human associations unquestionably became one of the outstanding factors in the evolution of human nature. The group, as such, must therefore be regarded as a causal factor in the development of man.

Such a theory as this does not lack plausible evidence. Chapin [3] summarizes the evidence somewhat as follows: (1) Life in societies was a powerful advantage in man's earlier struggles for existence against natural enemies. (2) It enabled him to build living quarters that protected him from severe climatic conditions, and that could not have been built alone. (3) It stimulated the development of language and with it, thinking. (4) Living together made it possible, also, for man to raise a larger number of offspring, thus increasing the chances of useful biological variations. Accordingly, group life led to an 'accumulation of biological gains.' (5) Survival was facilitated still further by opportunities for imitation. The brightest member of the group taught the more stupid members methods of getting food, self-protection, co-operation and the advantages of tolerance and sympathy, any of which the latter might never have learned by them-

[2] "Members One of Another." *Sci. Mo.*, 1917, Vol. 4, 534 ff. Quoted by Kimball Young, *Source Book for Social Psychology.* Knopf, 1927, 32 f.

[3] *Introduction to the Study of Social Evolution.* Century Company, New York, 1913, 102 ff. Cf. Kimball Young, *op. cit.*, 35 ff.

selves. All of these conditions led to a more and more varied and complex society, which at the same time became more secure and orderly, thus favoring man's evolution, particularly his intellectual progress.

Specific Ways in which Behavior Is Socially Conditioned. The interaction between individuals and the group takes a variety of more specific forms which it is within the province of psychology to study. Groups, functioning as units in themselves, set their own standards of conduct, and *these standards are factors always to be considered in predicting a performance of any individual within the group.* These include folkways, mores, customs, rituals, taboos, public opinion, moral and ethical codes, and laws. The individual whose behavior does not conform to these standards is generally punished, or ostracized by the group, but at least he is regarded with fear and suspicion. Considered as principles of living, these standards are holy possessions to be preserved against all odds. Thus the group control over the individual is persistent, unyielding and often very severe.

Folkways. Any mode of behavior that turns out to be expedient, that satisfies a present need, brings pleasure, or fulfills a wish, soon becomes accepted by the group as 'the right way.' In every society there is the right way to till the soil, to marry, to dress, to treat disease, to worship, to address strangers, to make war, to organize governments, in short, to do everything. These 'right' or traditional ways are *folkways.*

In primitive societies folkways often originate through false inferences. Sumner[4] gives the example of a party of Eskimos who had been hunting with no success. One of them returned to the sledges for some meat which consisted of a dog's ham. On his return with the ham-bone in his hand he saw a seal and killed it. Thereafter he and his comrades carried a ham-bone as an omen of good luck; it became the right way to hunt. In another instance a tribe of savages went on a hunting expedition and saw a large bird fly overhead. The expedition was a failure, hence thereafter if a

[4] Sumner, W. G., *The Folkways.* Boston: Ginn and Company, 1906. Cf. Kimball Young, *op. cit.,* 97 ff.

bird of this kind was seen while the tribe was out hunting everyone immediately faced about and went home.

Most of our superstitions, which are remnants of folkways, originated in the fashion just described. For example, if someone saw a black cat cross his path and shortly afterward had bad luck, he might conclude that under such circumstances all black cats must cause bad luck. The false inference made in any reasoning of this kind lies in regarding events as causally related just because they occur in sequence.

Mores. After folkways are practiced for a time the group begins to justify them. This raises them to the plane of welfare-doctrines; then they are called *mores*. Hence mores are folkways that are supplemented by faiths, codes or other standards of 'right' living. Religious practices and beliefs are mores; so too, are political faiths, ideas of property rights and even those commonplace social practices that determine when and how we shall eat, when and how we shall obtain our amusement, and when and how we shall regulate the contact of the sexes. Why is it that one must select his group when he wishes to talk religion, sex or politics? It is because mores have the influence and authority of facts. The person who tries to change the mores is ignored, ridiculed, attacked or feared; he is assailed if he defames the constitution of his country; he is regarded as a dangerous infidel if he teaches evolution; he is scorned as a faddist if he preaches the doctrine of the single tax. Indeed, any idea or act which does not fit into the mores puts the group at once upon its guard; any attempt suddenly to change the mores of the group brings about ill feelings and strife. For example, emancipation of the slaves in 1863 was achieved by outside force in opposition to the economic, political and social mores of the southern white population. Sixty years afterward there still persist many of the original differences between northern and southern mores that were occasioned originally by the adaptation of southern social practices to slavery.

Taboos. Taboos are mores of negative rather than positive significance. They tell the individual 'thou shalt not' instead of 'thou shalt,' hence they are called the 'police' of the mores. The orthodox Jew is forbidden to eat pork; sacred

objects must not be touched under penalty of injury from a supernatural force; fish must be eaten on Friday; and certain words must not be uttered in polite society. A person must not attend class in his bathing suit, and he must not play certain games on Sunday. The violation of taboos like these brings with it the same opprobrium as the violation of a positive injunction. Consequently few are the individuals in any social group who have the inclination to defy taboos until their social significance has waned.

Development of Mores into Customs and Laws. When mores are sufficiently rooted to become permanent social heritages they are known as *customs*. Then they are rules of conduct to be accepted uncritically and to be supported by common sentiment. When their usefulness has been demonstrated and they have received the sanction of constituted authority they become laws. There is a rather striking psychological difference, however, between custom and law. The former is an involuntary, a matter of fact performance; the latter is highly conscious and voluntary; it is a prescription of conduct that is constantly to be kept in mind.

Strange as it may seem mores are frequently more stable than laws; they function where written laws fail. Reasons for this curious fact are not hard to find because frequently laws are enacted by a few individuals for some special gain, and hence fail in the support of the others, while mores represent deeply seated convictions of the group as a whole. Moreover, the machinery for the enforcement and annulment of laws is unwieldy, as a consequence of which certain laws are held in contempt and others are considered obsolete.

The Effects of Social Conditions upon the Individual

We have just studied some of the ways in which the individual's behavior is conditioned by his social environment and we have found that, in general, he acquires a great variety of social attitudes, habits and beliefs which are sustained only because of his relationship to the group. Let us examine more closely the effects of group life upon the individual. Specifi-

cally, (1) he develops characteristic attitudes toward outstanding personalities in the group, or he becomes a leader and assumes characteristic attitudes toward the masses. (2) He develops a sympathy for or a hostility toward other groups, and among these attitudes are to be found religious, political and race prejudices or sympathies. (3) Under certain conditions he subordinates his personality to a feeling and purpose held in common with others; he participates in crowd behavior. (4) He acquires a host of character-traits which, taken together, constitute his personality, and (5) he develops a concept of self which is determined by his comprehension of the relationship he sustains to the group. As far as can be ascertained none of these attitudes and traits is native to the individual; each is a social acquisition. The child knows nothing of pride, conceit, humility, pity or gratitude; he has no race prejudices, no religious preferences and no political biases. All of these are acquired in a social environment.

Leadership and the Attitude of the Average Individual Toward Great Men. The *first* effect of group life upon the individual is the stimulation and maintenance of leadership and 'followership.' The leader is a person who possesses a striking personality, an unusual intelligence and a superior knowledge of the needs, strivings and beliefs of the group. His genius may take the form of an unusual ability, (a) to govern or organize, (b) to make articulate the vague religious and philosophical strivings and ideas of the group, (c) to lead in campaigns of aggression or defense which will save the group from destruction, or (d) to invent devices which greatly improve the living conditions of the group and satisfy its practical needs.

Whatever the reasons for the leader's position in society, the masses accept his judgment unquestioningly, and with this surrender of judgment they also subordinate their own initiative and will. Thus it happens that the masses become dependent upon authority, and authority becomes a means of social control. So important has the leader always been in the development of human thought that history, until recent years, was little more than an account of the activities, exploits and

achievements of great men. The great man has always been revered, and frequently he has been worshiped as a God. In fact, the Gods of all religions have been personages endowed with extraordinary human powers.

Moreover, the group always takes for granted that the talents of the great man are for it to use, generally without compensation. The masses flock to him for consolation, cures, knowledge, advice, and for the products of his artistic and scientific genius. The more he gives the more they demand. Much of the leader's influence accrues, therefore, from the desire of the masses to believe in his judgment and to feel the effects of his powers. Indeed, it is the behavior of the group that not only stimulates but *maintains* leadership. The astounding facts of unscrupulous leadership and the frequent rise of leaders in social crises bear out this point.

Close Relationship of Crises and Leadership. Probably the same social and economic conditions which produce crises also produce leaders. Conversely, during periods of prosperity and quiescence there is less need of leaders; there is nothing to stimulate the initiative of those individuals in the group who would be able to assume leadership should a crisis enliven them into activity. Were there not some degree of longing, striving or need, within the group, to be satisfied by his offerings, the potential leader would seldom if ever rise above the level of the masses. Otherwise, from the group standpoint there is no incentive for an interest in a leader should one appear. If he did appear under such circumstances he would most likely be regarded curiously as a freak or a crank, misguided and half insane, whereas in a genuine crisis this same individual might be hailed vociferously as a savior. Thus it is that great leaders are to a certain extent products of the circumstances under which they live. In part they are men and women who are capable of grasping opportunities and of making use of their talents in times of need. In part they are persons who are capable of making opportunities for themselves. In any event, we see evidence of the fact that an outstanding personality is a product of social causes.

Race Prejudice. Race prejudice illustrates the *second* type of effect induced in the individual by social con-

ditions. Park [5] expresses the belief that race prejudice is a fear-reaction which serves the purpose of limiting free competition between races. Where foreign races are not feared they are socially acceptable, provided there is no marked difference between cultural levels. In this country the utterance so often heard, "the negro is all right in his place" means in a last analysis, no doubt, that "in his place" he is a convenience rather than a competitor. That the race cleavage between white and colored persons in the United States is a social situation of economic origin is indicated by the fact that the negro is accepted in other countries, while here he must "keep his distance." Also, that such a cleavage is not 'instinctive' or inherited is clearly evident from studies of child behavior, because white and colored children play together with no awareness of a race difference until they are taught by their parents to avoid one another.

The Conditions of Crowd Behavior. The *third* effect of group life upon the individual is the loss of individuality, of critical analysis, and of emotional stability in a crowd or mob. *First,* among the conditions under which a group becomes a crowd is a goal or objective common to the behavior of all individuals within the group. *Second,* there is a common motive or desire for action. *Third,* there is a disturbing factor from without, generally a certain group or a person who symbolizes it, toward which the given group assumes an attitude of fear, hostility or revenge. *Fourth,* there is the appearance of a leader who keeps the group consolidated, leads it on, and as a representative expresses its desires.

Characteristics of Crowd Behavior. (1) *The Primitiveness of Crowd Reactions.* According to Martin [6] primitiveness of attitude and thinking is an outstanding characteristic of crowd behavior. To illustrate, beliefs on the part of the crowd do not require proof; they persist because they are demanded. There are no problems for the crowd because they are always settled in advance; consequently, logic does

[5] In introduction, *The Japanese Invasion,* by J. Steiner. Chicago: A. C. McClurg and Company, 1917.

[6] Martin, E. D., *The Behavior of Crowds.* New York: Harper and Brothers, 1920.

not restrain its behavior. Then in reverse ratio as they are able to think, members of the crowd become suggestible; they accept ideas uncritically and surrender readily to an emotional appeal. The vulgar, the tawdry and half-true assume the dignity and importance of well established facts; catch phrases, slogans and magic words perform such tricks as only scientific information could achieve under ordinary circumstances. Even a crowd composed of intelligent persons will accept as truth the most absurd utterances, and applaud proposed plans which individually each man would scorn in derision.

(2) *Hostility in Crowd Behavior.* A second important characteristic of the crowd is its hatred of disturbing influences. Frequently this hatred assumes the form of a defensive attitude such as the delusion that it is being persecuted by some outside group, or that its principles are at stake, or that it is the victim of conspiracy and oppression. As a rule, a delusion of this sort is nothing more than a pretext for venting hatred. Thus we can understand the ease with which individuals participate in crowd destruction and murder. Even supposedly peaceful crowds, busy with moral and religious pursuits, may easily be turned into irrational mobs whose moral enthusiasm is not satisfied until it finds a victim. At any rate, if the desired victim is not available, a crowd is inclined to substitute someone else with a readiness which, according to Martin, can only be explained in terms of a powerful 'inner drive.' For example, a mob on the street, turned away from its coveted victim, heads in another direction and forthwith demolishes a store. Disappointed in its demand for a certain negro a lynching crowd may even attack and hang an innocent man. From the standpoint of the individual, therefore, we see in crowd behavior an exaggeration of emotional responses leading to a goal which under ordinary conditions would never have been established.

(3) *The Egotism of Crowd Behavior.* Martin tells us that crowd behavior is motivated by certain emotional reactions, perhaps more fundamental than fear or hatred or at least more persistent. Self-feeling would be an example of such an emotion. The motive for organizing into crowds may very well be a desire on the part of individuals to express

an ordinarily inhibited self-gratification. For example, the crowd is exceedingly jealous of its honor; it is utterly devoid of humor; its moral and religious motives are frequently mere pretenses or excuses; it proverbially insists upon keeping up appearances; and it thrives upon flattery. Moreover, *individuals become exalted* in crowd behavior and under the pressure of excitement they may exhibit themselves to almost any extent without shame. Throughout they are oblivious of the fact that the supremacy, power, praise and glory which they claim for their crowd *they really claim for themselves.* Witness the pride with which people wear badges and other group insignia; note how they will show off in a parade, and in other ways demonstrate their 'spirit'! What are these, asks Martin, but expressions of an 'exhibitionistic urge' which only the crowd situation permits?

(4) *Lack of Personal Responsibility in the Crowd.* The individuals in a crowd are divested of all sense of personal responsibility by the social situation yet they retain a powerful sense of moral duty; their aims are given over entirely to the crowd purpose. Since the crowd thinks in terms of concrete situations, never in terms of abstract ideas, concrete situations will follow one another in the crowd's imagination with no regard whatever for their logical sequence. Hence individuals may be persuaded to feel with great intenseness but with no critical analysis a moral duty which would not be obvious under different conditions. Such is often the case in lynching parties and in religious revivals.

(5) *The Idealistic Character of Crowd Behavior.* The crowd is idealistic and absolutistic. What it considers to be true is some fact or fancy accepted without analysis, yet in its own judgment its thinking is highly impersonal and its opinions are absolutely just. A crowd is utterly unaware that its attitudes exist only to satisfy self-feeling. Principles appear to the crowd as ends in themselves which must be vindicated at all odds and in this way self-feeling is gratified. Hence the crowd's uncompromising attitude and its lack of respect for persons. In order to protect its principles the crowd rationalizes its behavior to almost inconceivable limits and establishes sanctions and taboos which few if any of its

members dare to violate. In this way hostile groups or individuals are frightened out of resistance. Indeed, to resist is to be branded as an enemy of truth, morality and liberty. So it happens that the most antagonistic of crowds profess the same principles, as for example, two opposed political parties both of which appeal to national patriotism and 'drape themselves in the flag.'

So much for illustrations of Martin's point of view. While in many places in his book he resorts to terms like 'urges,' 'unconscious,' 'drives' and the like, to which we shall take exception later on, his discussion is rich in the portrayal of effects which the crowd exerts upon the individual.

Behavior Epidemics. Another type of crowd behavior is found in so-called behavior epidemics. For example, there was a famous crusade epidemic, lasting from 1095 to 1270, which on one occasion gripped children to the extent that combined efforts of parents, clergy and government were unable to quell their migration-mania. Another epidemic was the widespread belief in witchcraft during the 16th, 17th and 18th centuries, which lasted through the early period of American colonization. The rage for tulips in the 17th century, in Holland, was a curious example; it took the country by storm; paralyzed all other industries; necessitated the passage of special laws, and finally left thousands in a state of financial collapse! Of a similar nature are real estate booms like the Mississippi Bubble of 1717, the California Gold Rush of 1846, and the Florida Land Boom of 1926.

It is obvious that crowd behavior and behavior epidemics are socially and economically dangerous, but they are not without their antidotes.

Antidotes for Mob Attitudes. Professor Ross[7] suggests the following remedies for mob attitudes: (1) Higher education, in which standards and tests of objective truth are learned; (2) a sound knowledge of body, mind and society, which has more influence in raising the cultural level of the individual than have the exact sciences; (3) familiarity with the classics, a knowledge of the intellectual high-lights of the ages and their contributions to human thought; (4) influence

[7] Ross, E. A., *Social Psychology.* New York: Macmillan, 1908.

of sane teachers whose desire it is to have companions, not disciples; (5) avoidance of sensational newspapers; (6) sports which release the energies of the individual and stimulate co-operation; (7) country life which enables one to get away from the suggestibility of crowds; (8) life in a closely knit family (according to Ross, the northern races are better able to resist mental epidemics than the southern races because of the necessity, in the north, of banding in small groups like the family, thus remaining in one place and learning a few people well; since leisure in the south is spent in the street and public places, there is more opportunity in the warmer climates for crowd activities); (9) ownership of property which leads to conservatism, caution, and stability in behavior; (10) participation in voluntary associations where one gains an acquaintance with rules of discussion, learns to tolerate one's opponents, acquires a love of order and finds what it means to abide by the will of the majority; (11) an intellectual self-possession, an ideal which makes fads and crazes seem ridiculous; (12) a prideful morality, which raises the individual above the crudities and harshness of life, and (13) a religion which makes vital the rôle of love and sympathy in social intercourse.

We now turn to the *fourth* effect of the group upon the individual, namely, the growth of personality.

Personality and the Self as Social Products

Personality: Its Beginnings in Infancy. Probably one of the first objects which the infant sees and learns to recognize is his mother's face. It is not, we suppose, the face which an adult sees when looking at another adult, but a face in which eyes, nose, mouth and hair are not differentiated. It is a face-as-a-whole possessing certain characteristics to which the infant responds. It may be a 'friendly' face, or a harsh face, not defined by the infant in terms of these words for the infant knows no words, but defined in terms of relaxation, tenseness or excitement on his part. It is likewise with the manner in which the child is handled. He soon learns his

mother's touch and to differentiate, not between various degrees of pressure on different parts of his body when taken by his mother, but between the 'total feel' of his mother's handling and that of another person. He responds to this touch as a complex but unanalyzed stimulus, and this complex stimulus begins at once to produce irritability and nervousness on the one hand, or comfort and relaxation on the other. Gentle, easy, graceful and comfortable handling produce a different effect from jerky, rapid and stiff manipulation of the infant's body. Thus the infant begins to acquire the temperament of his parents and establishes the first types of response which gradually differentiate into his traits of character. The child's health, digestion, habits of sleep, and the like, also play a significant rôle in the development of his personality, as do the voices and the movements of persons within his range of apprehension.

There follows shortly another character-influencing relationship which is built up between infant and parent by the habits which the parent permits or forces the infant to acquire. Since at first the parent handles the child mostly in connection with the process of food getting, handling becomes incorporated in the stimulus-patterns which produce comfort and then becomes a goal-to-be-sought-after. The child's method of expressing his inarticulate desire is crying; he cries when he wants the comfort of being handled and he repeats the performance only the more when the parent gratifies that desire. Here the traits of aggressiveness, selfishness and dominance begin.

Personality in the Child. As the child grows older relationships with his parents become all the more important. If authority is too arbitrary and persistent, initiative may be crushed and the child made so dependent upon the aggressiveness of others that in later life he must always play the rôle of servant. If parents attempt no discipline whatever the child may become dependent upon the docility and submission of others and unable to adapt himself to the more severe social environments which he will almost certainly find outside the family. As a consequence he must forever play the rôle of master. So it is that temperance in discipline and in

all attitudes toward the child is essential if he is to acquire a well-balanced personality.

This principle holds equally well in the later years of growth. The shy, silent, sensitive youth who feels himself underrated by his associates and is constantly looking for abuse, slights and criticisms from his comrades or members of the family, may be the very one whose desires were neglected in the home, whose opinions were scorned, and whose questions were ridiculed. Under such circumstances what opportunity has any youth for the development of self-confidence and self-respect? Where are the joy and success, so important in the stimulation of initiative? And if, as sometimes happens, the growing child is permitted no freedom by overanxious parents, is allowed to run no risks, to express no desires and overcome no difficulties, to launch no adventures be they so harmless as exploring the unknown world beyond the back hedge, those intangible qualities of courage, vivacity and aggressiveness will inevitably fail to develop. In a social environment of this nature 'inferiority complexes' find fertile soil in which to grow.

The Projection of Parents' Ambitions on Their Children. Our earliest memories are likely to be of pleasant or unpleasant relationships with our parents, of wishes not fulfilled, of ambitions thwarted, of opportunities which our parents gave us or did not give us either through force of circumstances or by choice. Later, when we rear children of our own we pledge ourselves to give them the opportunities which we lacked; we insist upon their interest in things which as children we wanted but could not have. Furthermore, unsatisfactory relations between mother and father affect the personality of the son or daughter because the parents identify themselves with the child in order to find in the child's achievements compensation for their own unfulfilled wishes.

Young[8] reports the case of a certain mother who prevented her daughter from marrying on the pretext that the girl should finish college and enter the teaching profession. It turned out, however, that the real motive behind the

[8] Young, Kimball, "Parent-Child Relationship: Projection of Ambition." *Family*, Vol. 8, 1927, 67–73.

mother's attitude was a desire to see her daughter achieve what she herself was not permitted to achieve. But the daughter made a failure of school teaching, lost an opportunity to marry and was forced to remain home "broken in spirit and unable to organize herself for any kind of valuable activity." Meanwhile, of course, the mother was utterly unable to comprehend her mistake; she had wished her daughter the best possible education and training for a profession; what more could she do!

A well-to-do father wanted to fulfill in his son the cultural and economic ambitions of his own youth. Unfortunately the boy was not brilliant and could not master the subjects which would permit him to enter the college of his father's choice. When the father consulted a psychologist and was told that his son had reached the limit of educability, he became hostile, attempted to force his boy to learn, threatened the psychologist and also the authorities of the private school in which the boy was being taught. "And a gentle personality of low mentality had to suffer through it all."

The Fundamental Aspects of Personality as Analyzed by Thomas. Personality is not a scientific term; to define it exactly is impossible, but it may be described as the total organization of the individual's reaction tendencies. It is that particular pattern or balance of organized reactions which sets one individual off from another. Notwithstanding the difficulties involved Thomas[9] grapples with the problem of personality, and seeks a solution in what he regards as four fundamental wishes. According to his view we are born, *first,* with a tendency always to be active and this activity is expressed in the desire for new experiences. We crave stimulation, and long for expansion; we are constantly wishing for something, anticipating something, attempting something. In short, we exhibit an aggressiveness which, if thwarted, shows itself in anger.

Second, opposed to aggressiveness is the desire for security, various forms of which are revealed in caution, conservatism,

[9] Thomas, W. I., *The Unadjusted Girl.* Boston: Little, Brown and Company, 1923.

and apprehension of the new and strange. Upon this desire for security depend our regular habits, our systematic work, our occupation and our accumulation of property. Its defeat initiates fear.

Third, there is the desire for response from another person, especially one of the opposite sex. Listen to lovers talking, and note how often one puts the question to the other, "Do you love me?" The desire for response is not alone sexual. Self-feeling must be satisfied, hence devotion to family, club and church, and hence all manner of self-sacrifices and philanthropic deeds.

Fourth, there is the desire for recognition. We not only want response but also an articulate assurance on the part of the group that we are noticed and appreciated. Artists, musicians, adventurers, scientific researchers, social climbers, politicians, statesmen, all strive for a recognition without which they would not be able to carry on. And if the individual fails to secure recognition by positive means he obtains it by developing negativisms such as extreme humility, martyrdom, an unwillingness to co-operate, illness and a great variety of psychopathic conditions. In these latter attitudes the self is exalted by the attention it receives from the group, although the consequence is pain.

A Classification of Personalities. Another approach to the general problem of character is the attempt to classify personalities into types. There have been many of these attempts most of which have been unsuccessful because strictly speaking types are non-existent. Any classification, therefore, ends by grouping persons into artificial categories. Nevertheless, a simple classification judiciously employed is useful in systematizing the more general facts about personality. A typical classification is found in the grouping of individuals into *extroverts, introverts* and *ambiverts. First,* the *extroverted* person is one whose interests center in the outside world; he evaluates objects in terms of their *relationships to each other.* He is 'objectively minded,' thrives on environmental stimulation, loves physical activities and takes himself as a matter of course. He is quite certain either to dislike literature, art and philosophy, or merely to tolerate

them, for, according to Conklin,[10] he lacks aesthetic feeling and the finer sentiments. His hobbies are business, sports, club life or such activities as are motivated by the grosser emotional tendencies. On the other hand there is, *second,* the *introvert,* who always evaluates the world in terms of its *relation to himself.* His interests are reading, writing, painting, philosophy or any pursuit which requires reflective thought, meditation and an imagination in which the self plays a dominant rôle. He may be introspective, sensitive, dreamy, absentminded, and inclined to solitude. He generally lacks interest in business, sports or group activities of any kind. *Third,* there is the balanced individual whom Conklin calls the *ambivert.* The ambivert is interested both in outside affairs and in the 'inner life.' Conklin gives as examples, (1) the farmer who not only owns and operates a great ranch but is also a philosopher interested in abstract thinking and fond of literature, and (2) the university professor who at one time is absorbed in his writing, lecturing, or in abstract thought and at another time is engaged in co-operative enterprises and outside sports.

The Concept of Self. The problem of personality logically introduces the *fifth* effect of group life upon the individual, namely, the concept of self. By self is meant considerably more than is covered by the term personality, but its precise connotation depends upon the point of view of the investigator. Indeed, there are almost as many ways of defining self as there are points of view from which the problem can be attacked. We shall consider some of these points of view and then study the genetic development of the self-concept in the individual.

The Self from the Biological Point of View. From the biological point of view the self is the complex and highly integrated human organism functioning as a unit. Its unity is conditioned by anatomical structure, especially the nervous system which connects all parts of the body with a central region, the brain. Partly by means of this system the various organs of the body carry on their specialized functions in an

[10] Conklin, E. S., "The Definition of Introversion, Extroversion and Allied Concepts." *J. Abn. and Soc. Psy.,* 1922–1923, Vol. 17, 367–382.

orderly and harmonious fashion and by it also the human being makes a great variety of contacts with his environment.

The Self from the Standpoint of Individual Psychology. From the standpoint of individual psychology the self is the human organism-as-a-whole, consciously active, with a sense of personal identity, a knowledge of the past and a concept of continuity. This self has been variously described and interpreted by different psychologists (1) as a self-consciousness which is determined by a unique, unanalyzable mental process that is always open to observation, no matter what else may at the time be preoccupying the individual; or (2) as a complex experience which, under an analytical introspective attitude, breaks down completely into such simpler experiences as depend upon the sense organs of the body, especially the sense organs in the skin and muscles. In other words, self, according to the second view, is reducible to or composed of tactual (from the skin) and kinaesthetic (from the muscles) sensory processes, together with such visual imagery (mental pictures) or verbal imagery (silent use of words, particularly I, me, my, we, our, etc.) as represent and symbolize the activities of the individual. It is suggested that those who find an unanalyzable self-consciousness in their experiences are merely unable to reduce it to its basic processes. The method by which these analyses are made is introspection, a method which is extremely difficult to control and equally difficult to learn. The disagreement of opinion among psychologists regarding the ultimate nature of self-consciousness, as introspectively ascertained, is unquestionably in some measure a product of differences in training and attitude.

The Social Self. From the standpoint of social psychology, if not of general psychology, the self is an individuality, a personality, conditioned socially as well as biologically. The form and quality of the personality is derived from social contacts, while the possibility of having a personality rests to an equal extent upon the organism's inherited structure. In other words, personality is the socialized human being in action. The self from this standpoint is not to be defined in terms of the nervous system or of an assumed entity like an ego or consciousness, but in terms of an interaction between

the individual and the group. This is the self in which the psychologist is interested if his purpose is to predict and control human behavior. It is a self which reveals an almost unlimited complexity, and while normally it is always a unified whole it is constantly changing. The individual is not the same self today that he was ten years previous, and ten years hence he will have changed still more. In fact he differs in varying situations and even from one moment to the next. James very clearly brought out this fact in his famous Principles of Psychology (1890).[11]

To our children we are one self and to our club companions we are another; we hide the undesirable features of our personality when in one group, and carelessly expose them to another. A layman could without disgrace abandon a city infected with cholera, but honor would prevent a priest or a doctor from acting in a similar fashion. A soldier's pride forces him to fight or die under circumstances from which another man will escape without a stain upon his character. Persons frequently discriminate between their different social selves; as friends they exhibit pity toward one another in situations where they would show no mercy as officials. Indeed, any person will exhibit generosity in one situation and selfishness in another, ease before one group and awkwardness before another, polish and reserve on one occasion and roughness and unrestrained behavior on another.

The Psychiatrist's View of Self. The psychiatrist sees in the self a dynamic, striving organism having desires which are constantly seeking expression and gratification. This self comes into conflict with group standards. Normally it is able to surmount these difficulties, in fact to thrive upon them, but if taboos are too numerous, inhibitions too frequent and prolonged, and conflicts between biological cravings and desires for social approval too severe, the individual finds himself repressed. He will then shun the harsh and cruel world; he will rationalize his conduct in order to secure the pleasures that a socially standardized judgment condemns. He will compensate for his discomforts by deriving exaggerated happiness from approved pursuits and by wearing an outer shell

[11] New York: Henry Holt, 294–295.

ot appearances to hide the real self beneath. This is a personality which the individual himself is never able to see as others see it; it is a personality which under the right conditions will divide and become organized into an almost inextricable maze of dissociated selves, each functioning as a unit.

Genetic Development of the Self-concept. It was pointed out that the child's concept of himself is socially conditioned, and it was also noted that from the adult's self-consciousness relatively simple experiences may be abstracted which are known as sensory processes and have largely to do with the body. It is not known what rôle these bodily sensations play in the child's first vague concept of self, yet there is reason to believe that they are of considerable importance. In fact we can be certain of no other general conditions of the self-concept than the bodily and the social.

The infant evidently does not notice his body at first. His hands and feet are not 'associated' with himself for as yet there is no 'himself.' Nevertheless, beginning with his mouth, he gradually discovers various parts of his body until at the age of three he points to his ears, eyes, hair and many other features. The method and nature of these discoveries have not been established, but presumably the infant's experiences are originally general and undifferentiated in character, just as his movements are general and undifferentiated. It may be assumed that they resemble the adult's 'general bodily feeling,' or 'feeling of being alive,' and that from this general feeling there emerge those differentiated processes recognized by adults as tactual and kinaesthetic.

That the child's concept of self develops very slowly is demonstrated by his questions and comments over a period of years. For example he asks: "What is 'I'?" "Where am I, in my body?" "Will it come out?" "Will I change into someone else during the night?" "How many me's have I?" Ownership of objects is another important factor in the conditioning of the self-concept. The child learns that he may play with certain things and not with others; he grasps the significance of, This is yours, You can have that, No, that belongs to sister, That is father's, and similar declarations of those around him. He gradually comprehends the attitudes

of others until he learns to differentiate himself and his possessions from other persons and the things that belong to them.

Specific factors in social contact, like nicknames and epithets, color a person's concept of himself according to the significance which parents and others ascribe to these terms. G. Stanley Hall [12] told of a girl who knew no other name at the age of three than 'papa's devil.' Another was called 'baby' at the age of nineteen; another was called 'sissy' until she was eight years of age; still another was given the name of 'stick-in-the-mud' and knew no other until she was thirteen; a certain boy had no name except 'goody' until he was sixteen.

Then, during adolescence the concept of self expands by leaps and bounds. The individual begins to look into the future; he understands the meaning of character traits; his desire for response from others, especially from the opposite sex, suddenly mounts to levels previously unimagined. Overgrown 'egos' are most common during this period, either as a result of a sense of inferiority or of parental suggestion.

The concept of self receives its final touches when on the one hand the individual seriously formulates his ideas about God, immortality, and his relationship to the Unknown; he struggles with such abstract notions as the 'transcendental ego' in contrast with the 'empirical ego' and as a consequence acquires a still broader view of himself. On the other hand, when he enters a profession or trade in which occupational standards and attitudes brand him as a certain type of person, he is likely to conceive of himself finally in the light of his particular group and its social status.

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CHAPTER III

SOCIAL BEHAVIOR: METHODS AND PRINCIPLES

METHODS

The Measurement of Personality Traits. Experimentation in the field of personality traits and social attitudes is still in its infancy. The several hundred investigations already published do little more than point the way to future developments, for personality is so complex and variable a phenomenon of behavior that to work with it is difficult. Yet these attempts have been worth while, especially in revealing the extent of race prejudices, provincial moral standards, and superficial conceptions of social problems and political creeds. They have aided in uncovering the emotional aspects of human behavior and in revealing how all these attitudes and traits are socially conditioned.

When we reflect that the public has always been a prey to a multiplicity of 'psychological gold bricks' sold by quacks and swindlers and fostered by misinformed enthusiasts, we can not help but conclude that our present attempts at measurement, crude though they are, should be made as familiar to everyone as possible. For example, there are many today who still believe in *astrology,* one of the oldest of the false methods of measuring and determining character. Other fake methods are phrenology, the use of physiognomy and handwriting.

Among the traits and attitudes for which tests have been attempted are the following:

Social attitudes.....conformity to social standards
fairmindedness
openmindedness

Social attitudes.....	race prejudice
	public spiritedness
	moral judgment
	incorrigibility
	honesty, deception, trustworthiness
	numerous beliefs and disbeliefs
Traits of character.....	self-assertiveness
	self-submission
	self-estimation
	self-assurance
	extrovertiveness
	introvertiveness
Dispositions	cheerfulness
	optimism
	pessimism
	depression
	perseverance
	resistance to opposition
	suggestibility, effects of encouragement and discouragement, effects of praise and approval

It will be possible to discuss only a few of these tests as typical examples.

The More General Methods of Measuring Personality. The more general and least precise methods of studying personality are the analyses of biographical and autobiographical material and the use of case histories. Next in order is the attempt to analyze biography on the basis of psychoanalytic principles. That is, the early life of an individual, as given in biographies and historical records, is studied with a view of ascertaining those habits, attitudes and ideas which affected him in later life. More specifically, these studies seek to interpret the adult's interests, achievements, hobbies, likes, dislikes, sex relations and the like, in the light of early relationships with his parents and in the light of his childhood interests. First among such attempts was Freud's [1] psychoanalysis of Leonardo da Vinci. Since then there have been several others such as Clark's [2] psychoanalyses of Alexander the

[1] Freud, S., *Leonardo da Vinci: A Psychosexual Study of an Infantile Reminiscence.* New York: Moffat, Yard Company, 1916, 130.

[2] Clark, L. P., "Psychologic Studies of Notable Historical Characters." *Psychoanalytic Rev.*, 1921, Vol. 8, 1–21; 1922, Vol. 9, 367–401; 1923, Vol. 10, 56–69.

Great and Abraham Lincoln. Thomas and Znaniecki,[3] in their extensive study of the Polish peasant in Europe and America, have introduced another social method of studying personality. Here are to be found most interesting descriptions of changes in personality brought about by the migration of peasants from their native land to the United States.[4]

The More Specific Methods: Bogardus Social Distance Test. In a study of social distance and its origins, Bogardus[5] has devised a promising method for the measurement of social attitudes. In his first investigation he asked two hundred and forty-eight advanced students in social psychology to classify various races into three groups: (1) a group toward which they experienced a friendly feeling, (2) a group toward which they were indifferent and (3) a group toward which they felt an antipathy. The number of times a given race was placed in a particular classification roughly measured the social attitude of the students toward that race. The races which were listed in the aversion column appear in Table I.

TABLE I

NUMBER OF TIMES RACES WERE LISTED IN THE AVERSION COLUMN (BOGARDUS)

	Times		Times
Turk	119	German	38
Negro	79	Chinese	30
Japanese	61	Greek	19
Hindu	44	Hungarian	11
German Jew	42	Russian	8
		Pole	3
English, French, Rumanian, Spanish, Swedish, each			2
Canadians, Danes, Dutch, Norwegian and Scotch, each			0

In general the judges professed a friendly feeling toward the races to which they themselves belonged, and they characterized as indifferent their feelings toward races about which they had heard nothing. In most instances they admitted that their antipathies were largely dependent upon tradition

[3] Thomas, W. I. and Znaniecki, F., *The Polish Peasant in Europe and America.* Boston: R. J. Badger, 1918–1920, 5 Vols.

[4] For a recent summary of methods in Social Psychology, see Kimball Young, *Amer. J. Soc.*, 1927, Vol. 32, 953–971.

[5] Bogardus, E. S., "Social Distance and Its Origin." *J. of Appl. Soc.*, 1925, Vol. 9, 216–226.

and accepted opinion, not upon first hand evidence. Their sources of information were their parents, older associates, preachers, returned missionaries, newspaper articles, particularly those relating to atrocities, moving pictures in which members of the race in question were shown in villainous rôles, and the like. The majority of the 119 who placed Turks in the antipathy column confessed that they had never seen a Turk and, after all, knew very little about him aside from stories.

In a second investigation Bogardus[6] asked 110 subjects to indicate the 'social distance' from themselves which they would prefer members of different races to maintain. The raters checked a number of races against the following seven classifications, each classification representing a certain 'social distance':

I would be willing to admit members of 'X' race

(1) to close kinship by marriage
(2) to my club as personal chums
(3) to my street as neighbors
(4) to employment in my occupation in my country
(5) to citizenship in my country
(6) as visitors only to my country
(7) would exclude from my country

The average of the smallest numbers against which a given race is checked (or the number of groupings to which a race is admitted), becomes an index of the social contact range between the group doing the rating and the group that is rated. The minimum index is then represented by 1 or 7 and the maximum by 7 or 1. The social contact range as computed by Bogardus for the 110 raters varied from 1.18 for the Turks to 4.60 for the English. The raters were mostly Americans who were asked, incidentally, to specify their racial descent. It was evident from the results of this study that social distance varied inversely as closeness of racial kinship.

Binnewies' Study of Rural Social Distance. Binnewies[7] has recently used a similar technique in measuring group atti-

[6] Bogardus, E. S., "Measuring Social Distance." *J. Appl. Soc.*, 1925, Vol. 9, 299–308.

[7] Binnewies, W. G., "A Method of Studying Rural Social Distance." *J. Appl. Soc.*, 1926, Vol. 10, 239–242.

tudes of women students toward country life. He found that the rural social distance index varied as the judges' proximity to farm life. The six classifications used were:

1. I would prefer to marry a farmer.
2. I would prefer to live on a farm.
3. I would prefer to spend most of my time in the country.
4. I would prefer to spend most of my vacation in the country.
5. I would prefer to go into the country once in a while.
6. I do not care for the country.

The size of the index figure represents the extent of social distance. The rural social distance index of raters whose homes had been in the country was 3.54; those who lived in a community of 2500 or less averaged 4.43; raters from towns of 2500 to 10,000 inhabitants went up to 4.54 and those who came from towns of 10,000 and over gave the highest figure, 4.61.

Pitkin's Study of Moral Attitudes. Recently, also, Pitkin [8] has tried to measure roughly the moral attitudes of 500 representative men and women of this country between the ages of twenty and sixty. He asked his subjects to rank the ten commandments in the order of their moral importance. Table II shows his results.

TABLE II

ORDER OF IMPORTANCE OF THE TEN COMMANDMENTS (PITKIN)

The commandment	Order of appearance in the Bible	Relative importance as indicated by 500 judges
Against killing	6th	1
Honoring one's parents	5th	2
Against stealing	8th	3
Against bearing false witness	9th	4
Agaist committing adultery	7th	5
Against having other gods	1st	6
Against coveting	10th	7
Against making graven images	2nd	8
Against swearing	3rd	9
Agaist breaking the Sabbath	4th	10

[8] Pitkin, W. B., "Our Moral Anarchy," etc. *Century*, 1926, Vol. 112, 641–648.

It is interesting to note that in these results *social* mandates far outweighed the *religious* in moral importance. Even the 10th commandment outranked three of the four religious mandates. However, among the 500 judges there were 59 moral fundamentalists who rated the religious mandates higher than the social. The results lead us to believe that the more intelligent we become the more we differ in our moral judgments and the less importance we ascribe to purely religious mandates.[9]

The Character Profile. One of the newest developments in attitude and character testing is the comparison of individuals by means of profile charts. Bowden [10] investigated the personalities of forty student leaders in as many different colleges by asking them to fill out a questionnaire relating to emotionality, ascendancy of attitude or aggressiveness, submissiveness, extroversion, introversion, expansiveness, reclusiveness, insight into social situations, over and under self-evaluation and the lack or presence of self-seeking. He also tested them for intelligence and obtained scores on their ability to judge facial expressions of emotion from photographs. He found in general that the dominating traits of student leaders were ascendancy, expansiveness, extrovertiveness, high intelligence, good social insight and a fairly good ability to judge the attitudes of others from their facial expressions. Many were emotional and sensitive; they were dynamic individuals, who were easily distressed by reverses in social success. Some of them were unduly suspicious of hostile attitudes on the part of their associates, and felt without justification that they were not being appreciated. Figure 1 shows typical profiles.

[9] The study evidently intends to show that standards have changed since ancient times, but it is open to the criticism that the order of appearance of the commandments in the Bible may not have been their true order of importance as judged by a large group at the time the commandments were written. The commandments were not submitted at that time to a test of this sort, and we have no way of knowing what proportion of the population then were "fundamentalists." It is reasonable to suppose that moral criteria have changed through the centuries, but Pitkin's study does not prove the point at issue.

[10] Bowden, A. O., "A Study of the Personalities of Student Leaders in Colleges in the United States." *J. Abn. and Soc. Psy.*, 1926, Vol. 21, 149–160.

Professor Downey has made extensive use of the profile chart in testing 'will temperament.' She has attempted to measure freedom from emotional inhibitions, perseverance, resistance to physical opposition, resistance to negative suggestion and the like. Her tests have been as widely used as any methods of measuring character, but like all techniques of their kind they yield unreliable standards of performance

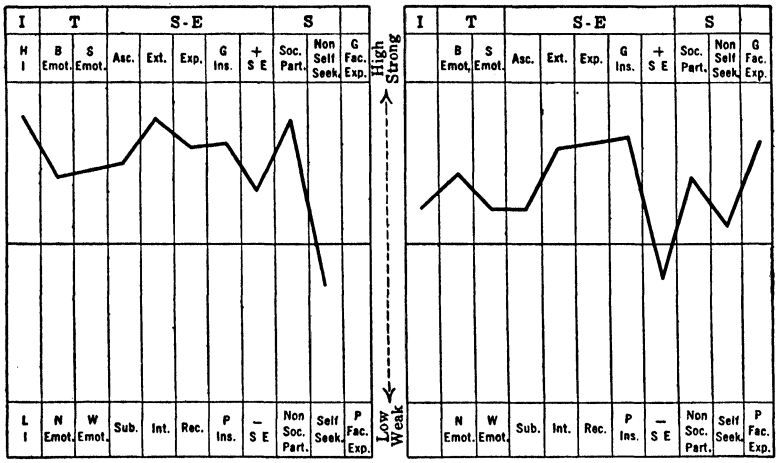


FIG. 1. CHARACTER PROFILES (after Bowden).

The first column from the left represents intelligence; the next two represent emotionality or temperament; the fourth is ascendancy, the fifth extrovertiveness, then expansiveness, general social insight, self-evaluation, social participation, self-seeking and judgment of facial expressions. Distance above the central line represents positive development, and distance below the line represents negative development of the various traits.

owing to the great variability of results from individual to individual. Figure 2 contains sample results obtained in the author's laboratory.

PRINCIPLES

Social psychologists have not only been experimenting with methods but also with explanatory principles. There are four main principles which have been selected at different times by different writers to account for social behavior: (1) Suggestion, (2) imitation (instinct), (3) sympathy and (4) habit.

(1) Suggestion. Suggestion commonly describes a

situation in which one person first accepts uncritically an idea or proposition communicated to him by another and then acts accordingly. In the earlier psychology suggestion was regarded as the cause of the idea suggested and this is still the layman's conception. Assertions like the following are frequently heard: "His actions are due to suggestion." "He obtained his idea through suggestion." "His ailment was cured by suggestion." When this process of communication is analyzed, however, the influence that one person supposedly exerts over another simmers down to a spoken word or to a gesture which the subject sees or hears. The energy involved

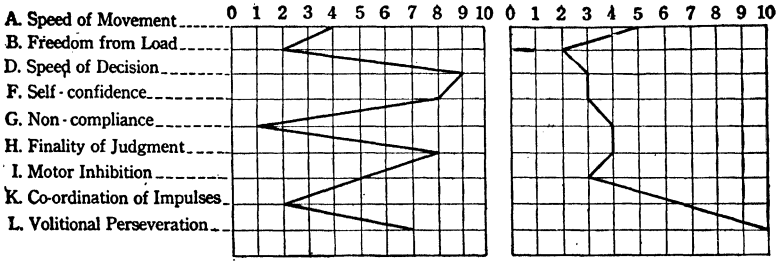


FIG. 2. CONTRASTING WILL-PROFILES (Downey Method).

Showing the relative rating, on a basis of ten, of two different subjects in the traits specified. In (A) the subject writes certain words at his normal speed; in (B) writing the same words as rapidly as possible is compared with (A); in (D) the subject underlines as rapidly as possible various adjectives that he thinks describe his character; in (F) he takes a memory test involving suggestion; in (H) he returns to test (D) and makes any desired changes; in (I) he traces a scroll as slowly as possible; in (K) he attempts to write a certain number of words as rapidly as possible within a given space; in (L) he attempts to change his handwriting as much as possible.

in the communication is confined to a very slight amount of light reflected from one person to another, or to the sounds that are produced in speaking. What then produces the suggestion?

The individual is not passive as the old notion of suggestion implied; on the contrary he is so active that the real source of influence is obviously *in the subject himself,* especially in his *attitude toward the person or group from which the suggestion is said to come.* The subject has acquired the belief that the assertions of the person in whom the suggestion originates must always be correct and that his

powers are more or less superhuman. This is likely to be true in relationships between pupil and teacher, the savage and the medicine man, the patient and his doctor, the layman and his priest, the witness and a clever lawyer, a crowd and its leader, any average person and an outstanding personality.

The *first* important condition of suggestion, then, is a *rapport* between two or more persons that on the one hand involves a willingness to believe and on the other, an authority and prestige. Deficiency of knowledge (but not feebleminded-ness) on the part of the subject is a *second* condition; ignorance, poorly organized knowledge and gullibility are closely associated. It is a commonplace observation that ignorance means the lack of contrary ideas with which to 'resist suggestion.' Thus it can be understood why children and uneducated, unintelligent adults are highly suggestible. Unfulfilled wishes constitute a *third* condition of suggestion; any proposition which apparently satisfies a longing is not only readily but eagerly accepted without criticism.

Striking examples of these conditions of suggestion are found in the mediumistic seance. The commercial operator or medium enjoys a position of prestige among his clients; people ascribe supernatural powers to him; they regard him with awe and accept his utterances with extraordinary credulity. The client or 'sitter' is usually a person who already believes in communication with the dead, or wants to believe in it, and attends the seance expecting to see spirits. Even those make good subjects who are not thoroughly convinced of spiritualism, but who crave any evidence which might substantiate their belief in personal immortality. In any case these conditions pave the way for an easy victimization of the unsuspecting 'sitter' through trickery.

It is illuminating to contrast the typical conditions of observation in a seance with the conditions of accurate scientific observation. *First,* in the typical seance the operator dims the room and prolongs the session; he delays the alleged appearance of spirits deliberately to induce fatigue and nervousness in the sitter. By these means he preys more readily upon the sitter's credulity, produces illusions more easily and guarantees his movements and the movements of his accom-

plices against discovery. On the other hand, instead of making the conditions of observation as poor as possible the scientific experimenter safeguards his observations against all possible sources of error. He avoids fatigue, secures optimum illumination and attempts to see as much of the events that are taking place as human ingenuity can determine.

Second, the operator of a seance confuses the sitter by a multiplication of the phenomena to be observed. He plans and times them in a fashion to induce misinterpretations. But the scientific observer isolates and minimizes the number of events to be observed in order that he may note with all possible accuracy everything that happens.

Third, the operator conducts the seance in a way to make indirect and incidental each pertinent observation by the sitter. These observations are always less accurate, less critical and less detailed. The scientific observer works under opposite conditions; he makes pertinent observations directly and focally in an effort to avoid superficiality, with its implications and personal inferences based on belief.

Fourth, the operator deliberately preys upon the sitter's beliefs, feelings and emotions in consequence of which the sitter assigns the desired values and significance to whatever he sees and hears. Contrast this with scientific observations which are intentionally impersonal.

Fifth, the sitter characteristically assumes an attitude of blind faith. In the scientific experiment the observer assumes an attitude of doubt concerning the adequacy of his observations. In general, then, the whole purpose of the seance is to deceive, and to conceal the real causes of the events that are taking place, while in the scientific experiment the whole purpose is to ascertain the truth and to reveal the real causes of events. It happens, therefore, that in the seance the closer the sitter's scrutiny the less he learns, while in the scientific experiment the closer the observer's scrutiny the more he learns.

Faith Healing. The success of faith healers depends upon the willingness of naïve patients to believe in the power of the healer. There have been faith healers throughout the history of mankind, some of whom have been sincere in the

belief that their powers were genuinely supernatural; others have been deliberate fakers and swindlers. Mesmer, a famous hypnotist and 'healer' of evident honest intentions, believed that he possessed an animal magnetism with which he exerted his influence over others. His fame was so great that crowds came from far and wide to see him and to be cured of their diverse ailments. That his power might help them, people fought their way to his platform in an effort to touch him, or to touch any object upon which he had laid his hand. When there were too many individuals to treat personally, Mesmer transmitted his magnetic power, so he thought and so the crowd thought, to a corps of assistants or to an object in the vicinity, for example a tree. At his direction assistants led certain patients, blindfolded, under the magnetized tree. It made no difference if the assistants selected the *wrong* tree; the scheme worked if the patient believed that the tree was magnetized, for he went away believing that he had been cured.

The Limitations of Healing by Suggestion. Suggestion has its limitations; so-called faith cures rarely if ever occur except in case the difficulty is nervous and not organic. Occasionally genuine cures are effected in hysterical persons suffering from lameness, blindness or deafness, but by a healer who is utterly ignorant of the reasons for his occasional successes. The average witness of these cures knows no difference between functional and organic disorders and as a consequence is likely to regard the 'healing' as a triumph of 'spirit' over 'matter.' In many instances patients who are suffering from an organic disease are led by the healer to imagine themselves well again, only to discover subsequently that they have been deceived.

Autosuggestion. From the foregoing discussion it becomes apparent that the major feature of suggestion is autosuggestion. The same attitudes, desires, and even fears which lead a person to accept a proposition communicated by another lead to the acceptance of a fact that he suggests to himself. Whatever one's theory may be of the ultimate efficacy of prayer, unquestionably much of its influence depends upon the subject's expecting that his prayer will be answered. If

the subject is living in a community or in an age in which prayer is a social custom this willingness to believe is only the keener. In the Latin countries there are many famous shrines decorated with crutches, spectacles, bandages and other evidences that the worshipers went away, after praying, with the conviction that they had been relieved of their physical infirmities.

Other striking examples of autosuggestion are observed in patients suffering from hysteria. Hysteria is a nervous disorder of the functional type, so-called, because no organic basis has been discovered for it. It is characterized by a variety of intermittent symptoms among which are emotional excitement and depression, suspicion, blindness, deafness, loss of sensitivity in the skin, hypersensitivity, loss of memory (amnesia), paralyses of the muscles, trances, somnambulisms (sleep walking a special case), splitting of personality and general heightened suggestibility. The case was once reported of a woman who *feared* that her neck was stiffening; gradually she acquired the *belief* that it was stiffening; then it actually stiffened until her head was drawn sharply toward one shoulder! Whenever she tried to look about her she was obliged to move her entire body. Physicians failed at first to discover the cause of her difficulty. Finally a psychiatrist, suspicious that her trouble was merely functional, clapped his hands suddenly behind her head. Frightened for a moment the patient automatically turned in normal fashion to see what had happened. The instant she discovered that her neck had moved, back it twisted into the contracted position. Later, when she was thoroughly convinced that nothing was wrong with her neck the contracture disappeared.

Autosuggestion is found also in normal daily life. The person who is constantly 'going around with a chip on his shoulder' convinces himself that others are continuously thwarting his plans, deliberately irritating him and ridiculing his ideas. The sensitive individual whose feelings are always being hurt finds the insults and unappreciative attitudes of others for which he is looking. These persons are incapable of observing a social situation accurately; their own attitudes blind them to the actual facts.

Hypnosis. The most striking of all examples of suggestion occur in hypnosis. Contrary to the popular conception the principles involved in hypnosis are the same as for suggestion anywhere, except that the conditions are deliberately exaggerated by the co-operative effort of two or more persons. In hypnosis the subject voluntarily submits to control by another person until he is willing to believe almost anything which the latter tells him and to attempt almost anything the latter demands. Hypnosis is not artificial sleep; on the contrary in its usual form it is an extremely limited mode of behavior determined only by a few stimuli which are under the control of the person toward whom the subject has assumed a complete co-operative attitude. The subject still sees, hears, feels and acts but in a manner determined in large measure by the hypnotizer. Unless the hypnotizer suggests otherwise the subject is generally unable to remember on coming out of the hypnotic state any of the events which took place during the trance, hence the trance is frequently called a somnambulistic state. Probably the phenomena of daily life which most resemble this state are dreams and absent-minded periods.

The Conditions of Hypnosis. We have stated that the conditions of hypnosis are those of suggestion in general. *First,* the subject must want to be hypnotized; he must be willing from the outset to accept instructions, to follow them closely and to believe the statements of the hypnotizer. If the operator is a person of authority and one having prestige in the eyes of the subject, the latter accepts suggestions all the more readily. *Second,* the subject must be uncritical; he must be ignorant; if he doubts the operator or if he attempts to analyze his own experiences he fails to accept suggestion. The *third* condition, wish fulfillment, is covered by condition *one;* the subject's desire to be hypnotized nearly always guarantees his receptive attitude. Cases are known in which a subject, desirous of being hypnotized, would not enter a trance because along with his desire he was too observing or critical of the hypnotizer's procedure and of the changes taking place in his own behavior.

Characteristic Phenomena of Hypnosis. Among the phenomena that may be elicited under hypnosis are, *first,* positive illusions of perception; the subject thinks he sees, hears, feels and tastes objects that are not present. *Second,* there are negative illusions of perception; the subject can not see or perceive objects specifically mentioned; he may be made to think that he is deaf or blind, or that his skin is insensitive (anaesthesia). *Third,* there are functional paralyses of the muscles; for example, the subject can not move his arm or leg. *Fourth,* the individual may become hypersensitive to stimuli (hyperaesthesia); he is able to read the date on a penny through the sense of touch. *Fifth,* he executes almost perfectly and with eyes shut simple acts which blindfolded he would perform very awkwardly under normal conditions (hypermotility). *Sixth,* there is the phenomenon of post-hypnotic suggestion.

Effect of Hypnosis on Organic Functions of the Body. It is possible, but of course inexpedient, to influence the vegetative functions of the body during an hypnotic trance. Limited changes can be induced in heart action, body temperature and blood pressure. Delboeuf, a famous French hypnotist, performed the experiment of producing two burns on the skin of a subject, merely with a cold object. He suggested that one would be painful but not the other. In the first case there appeared an ordinary blister which subsequently left a scar, but in the other there developed only a dry scorch which left no trace.[11] Other hypnotists have reported success in eliminating hunger in patients for a period as long as two weeks, during which time they would not eat. In still other cases movements of the bowels have been induced during the trance and also post-hypnotically at specified times after the trance.

Post-hypnotic Suggestion. During a trance the hypnotizer may suggest that at 12:30 o'clock the next day the subject will seize a crust of bread, leave the dinner table, put on his hat and coat, and walk up and down the street, eating the bread. At the appointed time the subject proceeds

[11] Quoted by James, *Principles of Psychology,* Vol. II, 612.

to carry out the instructions as normally as if they had been self-imposed, and without thought of being foolish. If asked why he is behaving in this fashion he gives the reason that he feels the impulse to do so, and resists any effort to persuade him to stop. On the other hand, normal subjects while in a trance resist any suggestion to execute acts of violence; they also resist similar post-hypnotic suggestions.

Inadvisability of Playing with Hypnosis. It is not advisable for the novice to play with hypnosis. Certain persons are much more suggestible than others and will easily slip into a deep trance resembling catalepsy, from which they may emerge later in a state of exhaustion. Occasionally the inexperienced hypnotizer may be unable to waken his subject. If this happens the subject will fall into an evidently normal sleep from which he will usually awaken in a few minutes, but occasionally not until after a lapse of several hours; it sometimes happens that the stupor is prolonged for a day or more. At any rate the possibilities of post-hypnotic suggestion justify the warning that 'parlor stunts' are dangerous, or at least should be avoided in the interests of the best mental hygiene. Under any condition hypnosis should be supervised or undertaken by one who has made a thorough study of the phenomenon.

Contrary Suggestion. There is another form of suggestion, characteristic of normal waking life, namely, contrary suggestion or negativism. Every one knows the danger of warning a child not to step in a water-puddle, climb a ladder or handle a knife. One evening at the dinner table the author attempted to persuade his young daughter to eat her dessert. "You will most surely like it," he said, whereupon she turned away from the dish with a pained and disgusted look, although on a previous occasion she had shown evidence of liking it. Ask a child to shake hands and note how often he thrusts them behind his back in defiant refusal! Suggest that Johnnie go outdoors to play and forthwith he enters a tantrum. Many difficulties with children are conditioned by too frequent attempts at suggestion; in fact to do something contrary is often a delight to the child, in which case the conventional methods of suggestion have the opposite

of their intended effect. These troubles are far reaching, for if the child is rewarded for obeying under compulsion he may acquire the belief that resistance is what the parent wants. In unstable individuals negativisms of this character may become extreme or abnormal as in the case of dementia praecox, a psychopathic condition in which the patient loses interest in affairs about him and eventually shows a complete loss of normal emotional reactions toward his family, friends and companions. He is then a 'recluse par excellence'; he refuses to talk, resists all efforts to stimulate him and at last pays no attention even to the physiological needs of his body.

Suggestion Not an Explanatory Principle. Our study of suggestion has centered around two important facts. *First,* the individual is not a passive victim of influence from without; he is actively co-operating with another person whether he is participating in normal social life or whether he is entering an hypnotic trance. This co-operative activity reveals itself in an attitude of acceptance, in a desire or willingness to believe, or in a wish which the individual is striving to fulfill. *Second,* given this kind of a situation various stimuli are adequate for the arousal of a conviction; the stimuli may be any act of another person, a spoken word, a gesture, dressing in a certain way, attending church or what not. Suggestion thus describes a process of interaction between individuals; it is not an explanatory concept. It is not the cause of social behavior; the cause lies in the subject's attitudes and in the behavior of his associates.

The Problem of Imitation. Imitation was the *second* phenomenon selected by social psychologists as an explanatory principle. Imitation is acting as others act; a performance of one person is the occasion for a similar performance by another. The older psychologies taught that imitation was an instinct, but this view has been abandoned. Indeed, it may be doubted that imitation is in any sense of the term a causal agency in behavior. It is true that one person smiles when he sees others smile, runs in a certain direction when he sees others run, looks toward the top of a building when he sees others doing it, follows the same customs, acquires the same habits in daily life, dresses much the same and takes

up the same fads and fashions as do other persons. When one child plays with his blocks, others around him want to do the same thing. Even in animal behavior similar events occur, for when one bird of a flock takes wing the others follow; when one cow finds a hole in the fence the rest of the herd escapes also.

Peterson's Substitutes for Imitation. Peterson[12] has written one of the best critical discussions of the problem of imitation. *First,* he believes that many activities supposedly of an imitative character may be ascribed to a similarity of bodily organs and to the fact that all members of the species respond to similar sets of stimuli. Since all human beings have hands that are very much alike, they manipulate objects in a similar fashion. *Second,* all members of a certain group discover that to act in a particular way is economical and time saving, regardless of the way in which other groups act. All individuals of approximately the same intelligence similarly evaluate what is economical and what is not. *Third,* when members of a group do not conform to the behavior of those around them they suffer embarrassment and become disagreeably self-conscious, hence the motive which minimizes lack of uniformity in social behavior. *Fourth,* practically everyone seeks the approval or friendship of others as a reward for his behavior; this necessitates acting very much as they act. *Fifth,* customs and habits of the group are drilled into the individual from his early childhood; he learns the mores under compulsion and through fear of punishment, not through voluntary imitation. *Sixth,* the individual is forced by circumstances to learn his native language not through imitation but by 'trial and error.' *Seventh,* the behavior of others brings to the notice of the individual those objects and situations to which he is capable of responding, but of which he had hitherto been unaware; in this class of objects belong articles of food, dress and toys. *Eighth,* the individual submits to the influence of propagandists, enthusiasts and specialists when they are present, because to resist them brings

[12] Peterson, Joseph, "Imitation and Mental Adjustment." *J. Abn. and Soc. Psy.,* 1922–1923, Vol. 17, 1–15. Reviewed by Kimball Young, *op. cit.,* 245 ff.

discomfort and opprobrium. *Ninth,* it is possible that the complex organisms, including man, inherit special mechanisms whose function is automatically stimulated by the use of the same mechanisms in others. Yawning and smiling belong to this category. *Tenth,* the individual may find that he forges ahead more rapidly in society, or otherwise finds it advantageous, to copy the actions of others.

Many of these explanations reduce 'imitative behavior' to modes of response elicited by similar stimuli although carried out at the same time by more than one organism. While explanations of this type seem plausible, the sixth and ninth are open to objection, the sixth because of the doubtful character of the 'trial and error' explanation of learning (see page 266), and the ninth because it is questionable whether the behavior of any complex organism is automatic. If seeing another person yawn makes one feel sleepy, one is likely to yawn also; if seeing another person laugh makes one feel happy, one is likely to laugh, but otherwise, not. It is probable, therefore, that in any case of genuine imitation the individual is exhibiting a goal-activity, which means *that the goal and the situation arousing the goal explain imitation, not imitation the goal.* Moreover, it is certain that imitation is not a basic mode of behavior.

There are primitive varieties of response, such as mimicry, (*e.g.,* a toad's skin takes on the color of the immediate surroundings) which have been misnamed imitation. There are also instances in which human beings copy the mannerisms of their intimate associates, apparently without knowing it. But it is not necessary to assume that goal-activities must be deliberately purposeful. We are constantly setting up goals and reaching them without realizing what we are doing at the time.

An Explanation of Imitation. The question may be raised, from what source are the goals derived which result in imitation? Are these not obtained from other persons and are they not caused by imitation and suggestion? To answer these questions adequately necessitates a return for the moment to a consideration of scientific method and logic. Imitation suffices to describe the behavior of acting as others

act, but to assert that one imitates because of an instinct to imitate only substitutes one term for another; it attempts an explanation of a phenomenon in terms of itself; it takes for granted all of the mechanisms of behavior that are inherent in imitation. Moreover, blind imitation is inconceivable; for how could one organism imitate another without perceiving what the other was doing, and without a goal in view? If perception and goal are necessary for imitation *then we already have in these phenomena a partial explanation of imitation;* they are some of the conditions under which imitation occurs. It should be clear, therefore, that whatever accounts for imitation interprets the behavior which imitation is invoked to explain.

In general these conditions are the same for imitation as for suggestion. On the one hand there is the neuromuscular system making insight and desires possible, and on the other hand there is a social environment of mores and attitudes. The infant smiles when the mother and father smile upon him after he has learned that smiling produces pleasant feelings or brings attention and reward. When the infant becomes a child he wants anything that he sees in the possession of others; he grabs his playmate's toy although he has one of his own just like it, because he wants to dominate the situation. In any case he imitates to relieve tension within himself and to produce relaxation. In fact any exhibition of a purpose or manifestation of a wish is a sign of a tension which the subject is attempting to resolve. When a person dresses as others dress he is imitating, to be sure, but he is primarily avoiding criticism. Criticism produces undesirable tensions and he avoids tension wherever possible; he conforms to the group in his ideals and purposes, as he conforms in his actions, in order to suffer the least amount of restraint and conflict.

Sympathy. The *third* mode of behavior which was mentioned on page 56 as an explanatory principle in social behavior belongs to the same group of phenomena to which suggestion and imitation have just been relegated. It is feeling as others feel, or reacting emotionally as others react, with the emotional behavior of another person as the stimulus.

It is not a principle that will account for uniformities in social behavior; it is another term descriptive of these uniformities. The causes are external to the sympathetic reaction. To illustrate: When a friend is bereaved we likewise feel sad and when we see a person in pain we are distressed; when we read of tragic events like the earthquake in Japan and the Mississippi River flood we at once sympathize with the victims; we imagine how we would feel in a similar situation. The help one person renders to others who are in difficulty is conditioned, *first,* by his own distress, relief from which comes only by removing the cause of distress in others. *Second,* his sympathy is conditioned by a sense of duty imposed upon him by the group. If he neglects his duty he feels uncomfortable, in which case he helps for the sake of securing social approval; the extent of his aid is proportional to his desire for praise. Hence sympathy, like imitation, hinges upon two sets of factors, the one to be found in the individual's interests and habits, the other in the social situation in which he lives.

History of Instinct as a Principle in Social Psychology. As early as 1877, in his famous essay on Physics and Politics, Walter Bagehot made one of the first attempts to explain social behavior in terms of imitation. During this same period Gabriel Tarde published a series of papers entitled "The Laws of Imitation" in which he attempted a similar explanation of custom, crime waves and other phenomena of social behavior. According to Young [13] these earlier treatises on social psychology led to the acceptance of *instinct* as an explanatory principle. James adopted it in 1890, and in 1908 McDougall made it the foundation of his social psychology; in 1913 Thorndike based his Educational Psychology upon instinct. Meanwhile, sociologists and others were experimenting with the concepts of suggestibility, imitativeness, sympathy, sociability, the gregarious instinct (Trotter), the urge for companionship (Bartlett), combativeness (Bovet) and sex (Freud).

[13] *The History and Prospects of the Social Sciences.* New York: Knopf, 1925, H. E. Barnes (Ed.), Chapter IV by Young.

The inclination to regard instinct in one form or another as an explanatory principle subsided when the logical difficulties (see page 168) and the dearth of factual material were realized. Following a long controversy textbooks in social and general psychology avoided the word instinct, and in many instances substituted for it the term 'drive' or 'urge.' But there were many who could not find in 'drive' or 'urge' an improvement upon the older concept of instinct and therefore turned to the remaining categories of behavior in an effort to find a cause for uniformities in human reactions. Among these uniformities was habit. It, therefore, claims consideration along with those which have just been discussed. It is the *fourth* of the principles mentioned on page 56.

Habit. In general the word habit refers to a learned response in any stage of development and permanency. Thus defined, habit is a more common form of behavior than suggestion, imitation or any of the so-called instinctive reactions. While there are numerous ways of classifying habits, they may be grouped for convenience into the categories that follow.

(*a*) *Social Habits.* Customs, fashions, folkways and *mores* are social habits. Moral standards are social phenomena created and maintained as habits develop and become fixed in the group; consequently they change only as habits change. Any performance is moral when it is an accepted custom or habit of the group, but otherwise it is immoral. Hence prostitution in one country is a crime; in another it is not; bull fights are a desirable and legitimate sport in one place, but in another they are sinful. Respect for law is a social habit without which law would be useless. Moreover, the economic as well as the legal structure of society is based upon group habits; credit hinges upon habits of paying bills; we deposit money in a certain bank because we feel secure in the honesty of its officials. Indeed, honesty is a social value which we ascribe to a certain kind of habitual behavior. Every individual acquires habits of thrift or carelessness, caution or recklessness, conservatism or radicalism, tidiness or slouchiness, courtesy and tact or crudeness and social awkwardness. Accordingly habits make possible an intimate

knowledge of persons and a reasonably certain prediction of their actions.

(*b*) *Intellectual Habits.* Certain habits are dominantly intellectual in character. For example, Mr. X is a farmer and like most people his interests center about his vocation; he interprets all problems in the light of his particular experiences. To him the weather is not a meteorological problem; rather, it is a practical question having to do with assistance or damage to his crops. Chickens are for him a source of income and food, not a domesticated species of wild fowl. The unruly neighbor's boy is not an abstract sociological problem but a nuisance to be watched and kept from tramping down his garden. So too, the biologist thinks in biological terms. To him the human body is a complex structure of nerve, muscle and bone, within which various physiological processes take place. To the artist, however, the human body is a figure of good or bad proportions, while to the moralist it is a possession not to be defiled by excesses.

(*c*) *Emotional Habits.* Mr. A is a chronic grouch; he complains so much that his life must be a continuous round of displeasure. His strawberries were almost ruined by the drought, and now, excessive rains are rotting the few that remain. At dinner his soup is too cold, and his meat is too rare. He never holds a good hand at cards. The winters are too cold and the summers are too dry. The family doctor is an ignoramus. And the automobile always has something wrong with it.

B is chronically suspicious; he imagines that everyone is plotting against him. The other night he read a paper at the Round Table Club. The members criticized it, therefore, they must have had a serious prejudice against him. For some reason they refused to give him the credit which he so justly deserved. No doubt they planned this display of hostility in advance, for at the banquet they were whispering and laughing. He felt very uneasy and self-conscious, and after the meeting adjourned he was glad to excuse himself. He went home and brooded about the whole affair. To cap the climax certain of these business men are scheming his downfall!

(*d*) *'Nervous' Habits.* Nearly everyone exhibits a certain number of nervous habits. The psychology professor adds 'er's' and 'ah's' to his words; the lecturer in economics utters an 'uhmger' sound each time he takes a breath; the sociology professor sucks his thumb; the physics teacher paces the platform; Mr. Brown scratches his head whenever he is called upon to recite; Miss Black blushes at the least excitement; Mr. Green bites his finger nails. And so it goes.

(*e*) *'Physiological' Habits.* There is a group of habits which may be called physiological because their exercise brings about specific organic changes in various tissues of the body. Addiction to drugs, the drinking of alcoholic liquors and smoking fall within this category. Indulgences like these are popularly known as habits to the exclusion of all other activities, save other *undesirable* habits; hence the widespread but erroneous notion that the term habit refers to something 'bad.'

(*f*) *Motor Habits.* Finally, there is a class of habitual performances which we may call *motor,* such as learning to walk, talk, swim, or to acquire skill in any sport, like tennis and golf. Learning to play a musical instrument, to drive an automobile, even such commonplace and menial activities as manipulating knives and forks, buttoning buttons, combing one's hair, the thousand and one little things we do in the course of the day's routine, are other examples. A motor habit, then, is any habit which involves the acquisition of muscular co-ordination.

The Tenacity of Habit. Once formed, habits are generally tenacious *for the outstanding reason that the individual does not care to break them.* Another reason is the fact that once insight is gained into the method of executing a given task that insight remains. The co-ordinations of riding a bicycle are difficult to learn at first, and yet after years of inactivity of this sort one's old facility may be regained with very little trouble. A man, grown old in prison, becomes accustomed to certain habits of living, and upon being released finds it difficult if not impossible to adjust himself to an entirely different set of conditions. Not infrequently, therefore, an ex-prisoner prefers to round out his life within prison walls. A watch is left at the jeweler's and meanwhile the

owner reaches into his vest pocket again and again to ascertain the hour of day. What man has not entered a barber shop at one time or another to be shaved, and taken off his coat and collar only to continue with his vest and to unbutton his shirt before he realized that after all he was not preparing for bed!

It is a frequent observation that old habits, successfully curbed under normal conditions, appear again under excitement and fatigue. Under these latter conditions voluntary control is lessened and there is a reverting to older and easier modes of behavior. The foreigner speaks English fluently so long as he remains calm and deliberate, but let him become excited and he jabbers in his native tongue. Under a nervous strain the smoker indulges more frequently in his pipe, and the drinker who has succeeded in cutting down his portion to a minimum makes more frequent trips to the secret cabinet!

Consequences of Habit Formation. Practically speaking, habits are both assets and liabilities. As assets they are routine performances which minimize conscious effort. Imagine a person's predicament in walking were it necessary for him to think how to place one foot before the other, or were he obliged carefully to estimate the position of his mouth while eating, or if he must struggle, each time, through the movements of buttoning his coat. Obviously he would always be trying to master the simplest tasks of life. Habit obviously introduces a saving in the day's work, lessens fatigue, and makes possible the continuous acquisition of new and more difficult performances. From a social standpoint it guarantees stability and uniformity, thus preserving law and order in collective behavior.

On the other hand, as liabilities habits confine us to the old and the traditional. While a wholesome conservatism is a matter of habit, that same conservatism may on occasion be a serious disadvantage. "The old way is good enough for me" is an expression which many of us have heard from the lips of our grandfathers, although a crop failure, or social ridicule hung in the balance. A business man may prevent his own advancement by wasting his energy in the performance of those routine tasks that might be delegated to a clerk.

It is the poor administrator who, as a matter of habit, burdens himself with details rather than assign such duties to his subordinates. 'Progress' involves the breaking as well as the forming of habits.

Trained as they often are in the old ways of thinking, it is difficult for people to accept new ideas; they fear the new and strange. Harvey's discovery that the blood circulated through arteries and veins as a consequence of heart action met with ridicule and suspicion. Years followed before other members of the medical profession accepted his view. Meanwhile the populace looked askance upon it, for it was a heresy! Similarly, scientists who first insisted that the earth was not the center of the universe met not only with criticism but with persecution and death! Unprogressive races bound down by primitive methods of warfare and inadequate methods of living have repeatedly given way to more progressive races. China is often mentioned as a backward nation held down by ancient customs, but as for ourselves, many of our laws are out of date. It is much harder to rescind an obsolete statute than to furnish society with a new one!

James' Famous Maxims of Habit Breaking. While discussing the practical aspects of habit it will be appropriate to mention James' famous ethical maxims, two of which he quoted from an earlier work by the British psychologist, Alexander Bain. *First,* in the acquisition of a new habit or in the breaking of an old one we should "launch ourselves with as strong and decided an initiative as possible." We can accomplish this best by making use of powerful motives, such as announcing our intentions to persons whose approval and respect we cherish. Also it is helpful to change our manner of living sufficiently to avoid situations that suggest the habit we are trying to break. *Second,* "Never suffer an exception to occur until the new habit is securely rooted." Breaking a resolve and attempting to taper off are likely to be disastrous. Early failure in the game is apt to discourage further attempts. *Third,* "Seize the first possible opportunity to act on every resolution you make and on every emotional prompting you may experience in the direction of the habits you

aspire to gain." *Fourth,* "Keep the faculty of effort alive by a little gratuitous exercise every day."

Habit Not an Explanatory Principle. We have obtained a superficial knowledge of habit, or better the habitual or perseverative aspect of behavior. We raised the problem in order to comprehend more clearly what various earlier writers in social psychology meant by habit, since they used it as an explanatory principle. But we find in habit, as in suggestion, imitation and sympathy, a concept which does not explain social behavior. Acts are not executed because of habit; *habits are these acts themselves.* Accordingly, for an explanation we must look again into the conditions under which the performance in question takes place. Why are habits acquired? We are as yet ready to consider only a general explanation in terms of two sets of conditions, one to be found in the individual himself, the other in his social environment. *Fundamental to habit formation are processes of growth and maturation of the neuromuscular system. These processes play an important part in the development of desires and insight.* With this equipment the individual proceeds in a social environment to acquire his habits. It is a continuous learning process conditioned in part by the modes of behavior which the individual finds around him. He learns in proportion to his desires and insight; if he is devoid of wishes he forms no habits. In order to form habits he must be under tension.

The Newer Conception of Social Behavior

The four principles have been examined around which social psychology has often been written and it has appeared that each of them is descriptive rather than explanatory. There remains for consideration a view which seems more acceptable in that it reduces social behavior to a fundamental law.

We were introduced in Chapter II to a phase of this newer conception of human behavior. *First,* the individual and society are part and whole aspects, respectively, of an organic

unit. In other words, the individual and the group are not two agencies functioning separately. *Second,* as we meanwhile pointed out, neither the individual's behavior nor the behavior of the group is to be explained in terms of instincts and habits. *Instead, we suppose that the behavior of the individual is to be accounted for in terms of his organic structure on the one hand, and his physical and social environment on the other. And the behavior of the group is to be accounted for in terms of its interrelated structures which are the personalities in the group, and in terms of relationships which one group as a whole sustains toward other groups.*

These principles are illustrated by the fact that personality, intelligence and desires depend upon a normal biological inheritance and upon group life. Every feature of behavior which we regard as constitutive of human nature, such as language, thinking, ideas of self, emotion or habit, is fundamentally a group as well as a biological phenomenon. It is both an aspect of social intercourse and a function of the nervous system. Without group life there would be no development of human nature, no emergence of the activities made possible by the neuromuscular structure of the organism. Conversely, without biological structure there would be nothing for social environment to work upon.

Interaction Between the Individual and the Group, a Configurational Phenomenon. In order to clarify this conception and suggest definite mechanisms by means of which the interaction-process between the individual and the group goes on, consider a lecturer speaking before an audience. He is on the platform, talking. He does not pause to scrutinize each individual face or to analyze the movements of each person; he does not hear the scuffling of individual feet. On the contrary, he grasps the total situation at once, apprehending the attitude of the group as a whole toward him. Figuratively speaking he senses the atmosphere of the situation; he knows that the audience is not with him. He then reacts to this *total situation* by exerting greater effort to interest them. Perhaps he tells an appropriate story; perhaps he introduces more illustrations or resorts to a number of dramatic devices in order to change the attitude of the group. In any

event the stimulus to which the speaker is reacting is the group, and not its individual members. It is an ensemble of noises, gestures and movements, not any isolated occurrence.

The same type of situation is illustrated by the late comer who enters a room in which several people have assembled only to find the atmosphere chilly, much to his embarrassment. What person has not confronted a group when it was evident instantly that cordiality prevailed? Again, let a person imagine himself deposited suddenly in the midst of savages. In this tense situation his first thought would be, What are *they* going to do?, not What is this, that or the other particular savage going to do? 'They' comprises an organic unit and the intruder fears the group as such. The fear stimulus is a social situation, effective but unanalyzed. We mentioned in the last chapter (page 39) that the child probably responds first to his mother's face as a whole. The total face-situation with a characteristic of its own, such as friendliness, sternness or hardness, is the stimulus that affects the child. A certain arrangement of stimuli, the face, is perceived as an organic unit, without analysis.

The Law of Configuration. *We may propose the law that any reaction of the human organism-as-a-whole is a unified response made to a total situation of some kind and, if to a specific detail, always to that detail in relation to other details. We may call this total situation a stimulus-pattern or arrangement of stimuli. This is the law of configuration as applied to conscious behavior.*

The reaction of the organism-as-a-whole is a pattern-reaction, or configurational response, and is not composed of isolated movements or a combination of discrete movements. Neither is it composed of discrete habits, instincts and wishes. It is an organized unit, and we call it a configurational response to emphasize the fact that it is, *first,* a response to a total pattern of stimuli, and *second,* that it is not a summation of discrete responses to discrete stimuli. If we regard such responses as made up of specific habits, instincts and wishes, we are attempting to account for an organic whole in terms of abstracted parts which taken by themselves are unrelated to each other; that is, they do not constitute a unity.

We may think of a 'configuration,' in general, as an organized system of energy, or system of movements, which, as a unit, affects other systems. The important feature of a configuration is the fact that it is a unit in itself unexplainable in terms of parts or 'elements'; rather, the parts or 'elements' derive their properties from the configuration of which they are members. A more general law of configuration may be stated, therefore, as follows: *Energy exists in the form of systems or configurations of stresses, and if one system affects another, the changes that take place are changes of the total systems. If a change occurs within a given system, the system as a whole governs the change.*

The lecturer's reaction to an indifferent audience was, therefore, not a matter of so much intelligence, so much habit, so much will, so much emotion and so much desire. It was a configurational response, so complex that *as a whole* it could be described by many adjectives. If we choose to single out the fact that the lecturer consciously put forth effort we call it voluntary. If we wish to emphasize the fact that he used methods he had previously learned and had frequently employed we speak of the act as habitual. If we wish to emphasize the fact that the functioning of a certain part of his nervous system, called the autonomic system (see page 214), was an outstanding factor in his reaction, we may call it emotive, and so on. He was not making use of several 'capacities' at once; he was performing a single act which is to be described according to the particular conditions and points of reference which we may have in mind at the time.

The view here set forth that the individual and the group constitute an organic unit, and that in turn any response of the individual is an organic unit or configurational response, conditioned by a stimulus-pattern, is not applicable alone to the behavior of human beings. It is a concept long recognized, at least implicitly, in explaining events in the so-called physical world. For instance, if we release an object from our hands it falls at once to the ground. This relatively simple event is the product of a very complex situation—the release of the object, its mass, the distance to the ground and the center of the earth. These are all factors none of which can be

separated from the others in explaining what the released object did, because physical, like behavioral events, are configurational and are conditioned by total situations. In other words, the gravitation system as a whole determines the movements of the released object. That the individual and the group should comprise an organic unit, and that movements made in response to a stimulus should constitute an organic unit, are no more difficult facts to comprehend by the principle of configuration than the simplest systems of physical energy.

Configurational Responses and the Law of Least Action. Our next step is to generalize, if possible, upon the conditions under which configurational responses take place. Let us return to our lecturer. Why was the audience indifferent? But first, what is indifference? It is a strain. The audience was bored; the seats were hard; the air was stuffy. The people preferred other activities than listening to an uninteresting speech. Accordingly, movements and attitudes on the part of the audience were not only symptoms of this strain, but they were also efforts to compensate for it. Had it not been inhibited by fear of breaking a long established custom and thus subjecting itself to criticism, the audience would have walked out to relieve itself of this strain, but courtesy to the lecturer prompted it to remain in the hall and to make the best of it.

We may suppose that any effort to overcome strain is an activity directed in a line of least action, and that it follows a general law which is applicable to many types of situations. *First,* wherever there are two or more potentials belonging to a particular energy system, motion takes place from the higher to the lower stress until an equilibrium is established or until the entire system is altered by outside forces. For example, wind storms depend upon the fact that in one locality warm air is rising, causing a low pressure area into which colder air currents rush from surrounding high pressure areas. An electric current will flow from a region of high potential to one of low potential. Between the center of the earth and points outside the center there is a differential of stresses as a result of which objects move, or 'tend' to move toward

the center. Water in two connected containers, the one full and the other empty, will flow until the level is the same in both.

Second, under particular conditions, tensions in one direction occasion counter tensions in the opposite direction until an equilibrium is established. To illustrate, stretch a piece of rubber and an equivalent counter tension is produced. Let a ball strike the floor and the internal pressure occasioned by compression of the object, as it strikes, causes the ball to bounce. *Third,* two opposed forces operating simultaneously may produce a compromise or resultant movement, as for example in the game of billiards.

These special cases may be subsumed under the general law that a body moves from one position to another over a route that is always the shortest (or the longest, longest notably in the case of light) when expressed in terms of energy times time. That is, in terms of the amount of energy involved in a given unit of time, action is either the greatest or the least, generally the least. This is known as the law of least action, or better, the law of stationary action.[14] The law holds in configurational systems of energy in which the potential energy of any particular body is derived from the system of which it is a member. For example, the weight of a stone is derived from the gravitation system in which the stone is found; that is to say, the stone would possess no weight if it were not a member of a configurational system of stresses.

There are certain other conditions implied by the law of least action. *First,* there are differences in stresses between parts of the configuration and these differences give potential energy (possibility of motion) to the resting body and kinetic energy (motion) to the moving body. The line of least action, therefore, is the most direct route in time from a position of high to a position of low stress. *Second, the point of low stress exists before movement commences and is the end toward which the movement takes place. In part,*

[14] The law of least action is the more general and accurate expression of principles variously known as 'the law of least constraint,' 'law of least energy,' 'law of greatest economy,' 'law of least resistance.'

the point of low stress directs the movement of the object; in other words its behavior is conditioned by a remote end which is established before action begins. Strictly speaking, the law of least action refers merely to the path taken by the moving body and not to the conditions which determine the path. Since, however, the path and its conditions are aspects of the same general problem it is convenient to think of the law of least action in connection with the configuration of stresses which determines the path. *Hence the laws of configuration and of least action imply each other.*[15]

[15] In the case of planetary orbits, a line of equilibrium with respect to a surrounding configuration conditions the movement of the planet; the orbit is the line along which movement is confined.

The law of least action as applied to conservative systems (where friction is not involved) dates from Maupertuis (*Mem. de l'Acad. de Paris,* 1740). An equivalent but broader principle, applicable to systems that are not conservative was advanced by Hamilton (*Phil. Trans.,* 1834). A non-conservative system, of course, becomes conservative if the system to which it loses energy is included. Accordingly, Hamilton's Principle and the Law of Least Action are treated as aspects of the same general problem. Webster states Hamilton's Principle as follows: "The time mean of the difference of kinetic and potential energies is a minimum for the actual path between given configurations as compared with infinitely near paths which might be described in the same time between the same configurations. . . . Nature tends to equalize the mean potential and kinetic energies during a motion." (Webster, A. G., *The Dynamics of Particles,* Leipzig: Teubner, 1904, 98, 99.) Note that Webster states "We shall now deal with a principle . . . somewhat broader than that which we hitherto called Hamilton's Principle *or* Principle of Least Action . . ." (p. 131). He also asserts that Hamilton's Principle is the most general of dynamical principles (p. 130). It is clear that the Principle of Least Action applies to configurational systems and that the path of least action is unintelligible except as we consider the conditions which determine the path. In applying this principle to human behavior, the human being is regarded as part of a physical system the totality of which is conservative, and the principle is always mentioned in connection with the conditions which determine the line of least action.

It is possible, of course, that upon the discovery of more detailed evidence, a more adequate basis than least action can be found upon which to construct a psychological system. Perhaps a corollary will eventually be formulated which hinges upon the fact that organisms are very unstable energy systems, and expend their energy with extraordinary readiness. Moreover, it should be borne in mind that the law of least action may not be the only basic principle underlying behavior. The law is adopted here merely as a suggestive working principle. In one form or another it has been suggested directly or indirectly as a basis of various kinds of psychological phenomena by Helmholtz, Mach, Avenarius, Ferrero, Lombroso, Helson and others. Cf. W. R. B. Gibson, "The Principle of Least Action as a Psychological Principle," *Mind,* N. S., Vol. 9, 1900, 469–495.

We suppose that the human being is an energy system which responds as a whole to forces acting upon it from without, and to disturbances from within. Presumably its behavior follows the same basic laws as the behavior of energy systems elsewhere. In human beings we describe behavior as an effort to overcome strain or to resolve a tension. The action continues as in other energy systems so long as an equilibrium of tensions is not established.

But this is not all. As we have just said, the low potential of an energy system functions as a limiting point at which action is complete. All action within the system in question takes place with respect to this point. One might say that it takes place with respect to this point as a remote end or *goal, and is directed toward that end.* Similarly in human behavior, action is always directed toward a remote end, or goal. Just as physical action stops when the limiting point is reached, so human activities stop when the goal is reached. Reaching the goal means resolution of the tension. *And as no physical action commences until there is set up a remote end, no act of behavior in living organisms begins until a goal is established.*

To return once more to the audience and lecturer, the audience, twisting and turning in its seats, was balancing two sets of strains, one, a desire to walk out, and the other, a fear of breaking a convention. It may also have been giving way to an avoidance of hard seats, which was a stronger reaction than the inclination to sit and listen relaxed to the speaker. It may have been compromising between boredom and a desire to appear interested. In any case it had a conflict of goals. If home had been the only goal it would have walked out. But it behaved, throughout, in the direction of least action. It was seeking a resolution of strain both by way of responding to the goal of home and to the goal of listening to the lecturer. The result, in the form of a compromise, was the most direct response under the existing conditions.

Why did the lecturer react as he did? Again to resolve tensions. The thought that he was unsuccessful was distress-

ing. Distress is tension, and any tension demands resolution. The horror of giving up the lecture, the desire to be approved, to hear the applause, and perhaps to propagandize his own cherished ideas are tensions, each demanding a resolution toward its respective goal. Expressed in conventional language only a satisfaction of the desire could remove the strain. As a tension, therefore, any desire demands its own resolution in the most direct way toward satisfaction. A wish demands its own fulfillment in the form of behavior over the most direct route toward the goal. Accordingly, the lecturer's behavior was the most direct procedure toward his particular goal or set of goals.

It should be remembered that the most direct behavior toward a goal depends upon the character of the goal and the character of the tension set up in the individual. For one person a certain goal may be more definite than for another, in which case the response of the one is more highly organized than the reaction of the other. The less effective adjustment made by the other person, however, was the most direct one in his case, and can not be compared, in terms of the law, with the more effective response made by the first person to the more definite goal. *In terms of the law there is no ineffective or wasted motion, no trial and error. It is a question of degree of configurational organization. Poor and good performances, alike, follow the law under different sets of circumstances.*

Relation of Human Tensions to Cultural Levels. Tensions in the form of desires mount with the increasing complexity of the organism and with its evolution to higher stages of intellectual development, for the higher the stage of development the more numerous are the goals. Civilized man has a greater variety of strains, more worries, more troubles than primitive man. The intelligent person suffers more tensions than the feebleminded; the critical individual undergoes more moral conflict than does the ignorant person.

The Conditions of Least Action Applied to Social Behavior in General. In general, therefore, folkways, customs, habits, and emotional reactions develop in a small way

at first as methods of overcoming tensions in arriving at goals. They become established as lines of least action. They are discarded only when on account of changed conditions and goals they commence to produce strains. Then new habits and reactions of all kinds come into existence as the procedures by which these latter tensions are overcome and the new goals are reached.

When an individual does not conform to the folkways of his group, tensions develop between him and the group. These tensions are expressed by the group as suspicion and fear. In primitive society the group not only showed fear of the variant or non-conformer, but even worshiped him. In civilized society, to relieve tensions of various kinds between groups and individuals the group segregates the variant if he is subnormal or criminal, and if he is a genius it vociferously hails him as a leader or shuts him up in prison as the case may be. What it will do with him depends upon its own conception of its needs or goals.

As for groups, as such, one group responds to another group in terms of race prejudice, cautious co-operation, tariff laws and armed force. In any case the outside group is a single stimulus-pattern and the group reaction to it is a unified response, a configurational reaction. Strains develop between groups as between individuals, and the responses of group to group, such as have just been mentioned, are procedures in terms of which strains are resolved.

To summarize, social behavior consists of interactions between the individual and the group, or between two or more groups. The group is a stimulus-pattern which, on occasion, disturbs a *status quo* within the individual or within another group by giving rise to a strain. The strain is exhibited in the form of behavior, and that behavior will continue until the strain is removed or counterbalanced in attaining a certain goal. Conversely, the individual variant in the group induces a group-strain and group-behavior will continue until the strain is relieved either by ousting the individual, or by making him conform, or by accepting him. The latter recourse involves a change of attitude on the part of the group, a reso-

lution of strain by changing the goal. All of this takes place either with or without a conscious analysis of the situation by the individual or by the group, and is in the line of least action under the conditions existing at the moment.

Primitive, simple reactions are the most direct means of arriving at primitive, simple goals; elaborate behavior on the part of educated and civilized man, requiring a long time for consummation, is the most direct way to reach an intricate goal. Thus in half civilized society a murderer is unceremoniously hunted down and killed, while in a highly civilized group he is arrested, given trial, a chance to appeal, another trial, a reprieve, and perhaps a pardon! It all depends upon the complexity of the goal and of the configuration in which the goal functions.

The tension balancing processes going on between the individual and the group or between groups take the form of suggestion, imitation, sympathy, mutual instruction, cooperation, hostile reactions and fear. Out of this interaction there emerges in the individual case personality and ideas of self; in the group there develop folkways and culture.

From the foregoing discussion of this principle which underlies social behavior it would seem that there is no necessity of positing a special set of fundamental laws to account for conscious behavior separate from the general laws that are applicable in the physical sciences. This conclusion logically follows from the assumption made in Chapter I, namely, that an ultimate distinction between mind and body is unwarranted. It must be remembered that there is, however, a difference between conscious behavior and the action of simpler energy systems. The former is conscious and purposeful in the sense that the organism apprehends the goal, and the latter, presumably, is not conscious; we are dealing with events in the two instances which are widely different in their complexity and variability. In each case, nevertheless, action is *directional* and follows the same basic law. There is, then, no conflict of principle between simple action in the so-called physical world, and the purposeful behavior of human beings and social groups.

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CHAPTER IV

INTELLIGENT BEHAVIOR: INDIRECT METHODS

The Problem of Measurement

Necessity of Measurement in Scientific Prediction. The conditions of social behavior are extremely complex and varied; they are so varied, in fact, that any attempt to control or predict an individual's activities proves extremely difficult. In this connection it should be remembered that the control and prediction of any event is proportional to the ease with which the event can be measured. Moreover, measurement generally implies units of time, units of distance and units of work or energy. The speed of an automobile is measured in units of distance and time; the power of an automobile is measured in units of horse-power; resistance to electricity is measured in terms of amperes and volts, and the heat value of food is measured in terms of calories. Each of these is merely a *convenient* value, but it is so selected that one unit of a given kind is equivalent or at least proportional to another of that same kind.

In Chapter III it was seen how Bogardus attempted to measure social attitudes in units of social distance. Let us give the most favorable attitude of an individual toward a given race the convenient value of 1, and the most unfavorable attitude the convenient value of 7. The results are meaningless unless it is assumed that these quantities represent certain amounts of prejudice or sympathy as the case may be; that for example, 2 represents a prejudice roughly half as great or a sympathy roughly twice as much as 1, that 3 represents a prejudice roughly one-third as great or a sympathy three times as much and so on. In other words the unit 1 sym-

bolizes a certain amount of attitude and these units are supposedly equivalent along the scale from 1 to 7, and equivalent in different people. Of course the equivalence of units can not be guaranteed in as rough a method of measurement as this, consequently the results are not used for purposes of exact prediction. Nevertheless, it is convenient for the sake of prediction to express scientific results wherever possible in a quantitative language of equivalents.

Significance of Changes in Measurements. Suppose that *A* took the social distance test at one time and rated the French 5; later he took the test again and rated the French only 2. It can be assumed that for one reason or another his attitude toward the French *had changed, that is, certain conditions of his social behavior had changed.* The next step is to discover what factors had been influencing him. Possibly a rough measure of the influencing factors is found in the drop from 5 to 2; at least the change in the rating suggests a problem to be investigated, and the extent of the change points to the relative social significance of the influences under which *A* had meanwhile been living.

Necessity of Limiting the Individual's Behavior. Measurements of this nature are crude and difficult to interpret, but to obtain them at all it is necessary to limit the conditions of behavior until specific and presumably uniform responses are elicited. This is exceedingly difficult to accomplish in a social situation. Indeed, until the individual's behavior is limited quite rigidly it is impossible to study him with methods even approaching exactness. To bring rigid controls to bear upon him means usually to isolate him from the group and to impose upon him relatively simple tasks. This involves eliminating many of the social relationships existing between the individual and the group.

It is possible to limit the conditions of behavior more exactly than was Bogardus' intention, without isolating the individual from the group. He can be controlled while still in the group by giving him special limited tasks to perform, which is a rough but convenient method of controlling the conditions under which he is behaving. This procedure, it must be understood, abstracts from his unmolested social behavior

a particular act which *does not naturally occur as an isolated performance.* When these tasks present the individual with problems to be solved the resulting behavior is called intelligent.

Two Methods of Studying Controlled Intelligent Behavior. There are two methods of studying controlled intelligent behavior, the direct and indirect. In the *direct method* a subject is confronted with a problem-situation under narrowly controlled conditions, and his reactions are watched. If desirable, he may be asked to relate how he undertook the task. A representative task would be opening a puzzle box or finding the way out of a labyrinth. The *indirect method* consists of giving the subject a battery of questions which he can answer with paper and pencil, in other words, an intelligence test. Here the written answers must be accepted for what they are worth as evidence of intelligence, since the individual's performance under changing conditions is not being observed.

The Selection of Material for Intelligence Tests.[1] The preliminary material for an intelligence test is selected merely from a common sense knowledge of behavior. So it was with Binet, who for several years prior to the formulation of his test scale in 1908, had been studying the mental development of his own children. With a knowledge gained in this work he selected a set of problems fitting the different stages of mental development in the child between the ages of 3 and 15. Later he added certain tests for adults. If about 65 per cent of children of a given age were able to answer the questions for that age he regarded the tests as satisfactory. A child who was able to pass tests designed for older children was regarded superior, and one who was not able to pass the tests for his age was considered inferior.

The Mental Age Concept. If a child is just able to pass the test which the majority of children of his age are just able to pass he is said to be mentally as well as chronologically of that age, and normal. This means, for example, that the average or normal eight year old child has a mental

[1] For a history of mental testing, see Kimball Young, *Ped. Sem.*, 1924, Vol. 31, 1–48.

age of eight years. However, if an eight year old child is just able to pass the ten year tests he is said to have a mental age of ten and is accelerated two years, mentally. If he is eight and has a mental age of only six he is retarded to the extent of two years of mental age. *Thus a year of mental growth becomes a rough unit of measurement.*

The Intelligence Quotient. In his revision of the Binet scale, Terman assigned values to each of the tests within the different year-groups and added certain questions making it possible to evaluate each single test in terms of a score composed of month-units. Terman also adjusted the items in the test and devised methods of scoring the items in such a way that each year represented approximately equivalent increments of mental development. This permitted measuring the mentality of the child, no matter at what age, in terms of the ratio between his actual performance and the average performance for his chronological age. Terman called this ratio an *intelligence quotient* (I.Q.). It is obtained by dividing the standard score for a given age, which is a point for each month, into the actual score obtained by a child of that age. The normal I.Q. is therefore 100. Thus, the standard score for six year old children is 72, a point for each month of chronological age. Suppose a six year old child passed all the seven and eight year tests; he then obtained a score of 96 which gave him a mental age of eight and an I.Q. of 133. Had he passed only the five year tests he would have an I.Q. of only 83. There are obvious advantages of the I.Q. over the mental age as a measure of intelligence. A child six with a mental age of three is relatively more retarded in mental growth than a child fourteen with a mental age of eleven. Accordingly, to interpret a mental age properly one must know the individual's chronological age. On the other hand an I.Q. classifies an individual either at the age of six or at some other age, like eleven, in approximately comparable terms.

Classification of Intelligence Levels According to I.Q. I.Q. classifications are not reliable beyond the age of about fifteen years. Because of this relatively uniform significance of I.Q.'s under the age of 15, it was possible for Professor

Terman to establish the following classification of intelligence levels.[2]

TABLE III

INTELLIGENCE LEVELS ACCORDING TO I. Q.'S

I. Q.	Classification
Above 140	Near genius or genius
120–140	Very superior intelligence
110–120	Superior intelligence
90–110	Normal or average intelligence
80–90	Dullness, rarely feeblemindedness
70–80	Borderline deficiency, often feeblemindedness
below 70	Definite feeblemindedness

Practical Classification of Intelligence Levels on Mental Age Basis. On the basis of tests like the Stanford revision, individuals are classified as feebleminded who have reached the age of 15 or 16 with a mental age below 12.

Persons whose mental age is one year or less are helpless. All those of 3 years of mental age or under are called idiots; they can not learn to work or play except in occasional instances. Persons from 4 to 7 years mental age are classified as imbeciles, the higher grades of which can learn to perform simple tasks. The mental age range from 8 to 12 constitutes a class known as morons. Low grade morons are able to perform a variety of routine tasks under supervision. The high grade morons can learn fairly complicated tasks such as using machinery, caring for animals and gardening, but they need occasional oversight because they can not plan and show almost no initiative when things go wrong.

Types of Intelligence Tests. There are two general classifications of intelligence tests; first, group as opposed to individual tests, and second, language as opposed to performance tests. Performance tests avoid the use of language, and are especially adapted for the examination of foreigners and illiterates. Group tests are relatively late developments in testing methods, while both the performance and language types of individual tests are of fairly early origin.

[2] Terman, L. M., *The Measurement of Intelligence.* Boston: Houghton Mifflin, 1916.

Examples of Items in Group Intelligence Tests. The tems which comprise an intelligence test require the subject :o apprehend various kinds of relationships, especially abstract ·elationships. The following are sample items of a test making use of same and opposite meanings. The individual is ısked to draw a line under same if the two words of a pair nean the same, and to underline opposite if the two words ıave opposite meanings.

low-high	same opposite
shy-timid	same opposite
reverence-veneration	same opposite
amplify-condense	same opposite

A greater variety of relationships is involved in such a :est as the following, which is called an analogies test.

shoe: foot:: hat: VEST SCALP KNEE HEAD
tolerate: pain:: welcome: UNWELCOME NUISANCE DESIRE PLEASURE
picture: see:: sound: HEAR NOISE OPERA EAR

What word, for example, bears the same relationship to hat ıs foot bears to shoe?

Still a different method of testing the comprehension of ·elationships is illustrated by a test like this in which the indi·idual is instructed to check the best answer.

Everyone should be educated because:
.....leaders are educated.
.....it provides employment for teachers.
.....everyone should know how to read.
...X...it makes a person more useful.

The following are samples of an information test often used because the range of a person's information is roughly proportional to the ease with which he apprehends abstract relations. The instructions are to underline the word which best completes the sentence.

Snow falls in AUTUMN SPRING SUMMER WINTER.
The terrier is a GOAT RAT DOG FISH.

Bile comes from the KIDNEYS LIVER SPLEEN STOMACH.

John Sargent was a well known WRITER STATESMAN SCIENTIST PAINTER.

Reasons for Large Number of Items in an Intelligence Test. In constructing an intelligence test large numbers of items are used for several reasons. *First,* with individuals raised in different environments and having different life-interests, a similar score in the test will not mean the same for one person as for another unless the items are sufficiently numerous to give each person an equal chance. *Second,* there must be a sufficient number of items graded in difficulty to differentiate those persons who can comprehend only the simpler relationships from those who are able to grasp more complex relationships; there must be an appropriate number of items not too hard for dull individuals and not too easy for individuals who are brilliant.

Third, a wide range of facts and relationships must be covered to avoid making a test of specialized interests and aptitudes.

Fourth, the items thus varied and graduated must yield results that can be expressed in terms of numbers, *and these numbers must represent the relative position of the individual in the group. His achievement must be compared with the average of the group.* To ascertain this relative position of the individual in the group the results of the test are treated statistically. Accordingly, large numbers of varied items are useful in reducing the size of chance errors.

Statistical Procedures

Necessity of Checking a Test Against a Criterion. If a test is to be applicable to conditions in life the results which it yields must bear some definite relation to the individual's achievement in life so that a prediction can be made on the basis of the test. In other words the test must be checked against a *criterion.* The criterion may be grades in school, teacher's estimates of brilliance, success in the vocations or

what not, provided it can be *measured.* The checking of a test against a criterion is accomplished by means of a statistical method called *correlation* (see page 100). Some of the mathematical procedures upon which correlation is based are to be discussed briefly in the following pages.[3]

The Frequency Distribution. Measurements dealing with mental traits, like measures dealing with physical traits, fall into what is known as a *continuous series.* Any unit of measurement used in obtaining this series is chosen as a matter of *convenience,* not because there is a unit existing in nature corresponding to that particular unit of measure. There is no unit in nature corresponding to the inch, yet height is measured in terms of inches, neither is there any unit corresponding to the pound, yet weight is measured in pounds.

Suppose that ten thousand men, thirty-five years of age, have been weighed. There would not be an equal number of men weighing 85, 95, 105 and 115 pounds, respectively, on to the heaviest which might be 245. There would be a certain weight, perhaps 165, which would represent more individuals than any other given weight. Then there would be a large number weighing around 160, but not as many as would weigh 165; likewise a large number weighing 170 but not as many as would weigh 165. With 165 as a convenient starting point, and using ten-pound intervals, there would be found among these men fewer and fewer who weighed each of the smaller amounts, until either extreme of the range of weights had been reached. Furthermore, this tapering off of the numbers of men in each of the weight-groups would occur at about the same rate going either up or down the range. There would be a *continuous* series of measures from lowest to highest with a known frequency of any given measure along the series.

Normal Curve of Distribution. These frequencies approximate a theoretical curve when properly plotted (Figure 3).

[3] It is beyond the scope of this book to discuss the more technical procedures that are necessary in standardizing the mental test and in checking the reliability of test results. The knowledge required for an adequate use of statistics necessitates a special course of study, at least more time than can conveniently be afforded in a beginning course in general psychology.

The distance of this curve from any point along the base line represents the number of times a particular measure occurred. Note, for example, that the measure occurring the geatest number of times was 165 and that the measures occurring the least number of times were 85 and 245. A curve such as these frequencies approximate is called a curve of normal distribution of measures because it holds in so many instances in which a heterogeneous group of related objects is measured for a particular trait.

Interpretation of the Normal Curve. A normal distribution of measures is obtained in a situation where no attempt

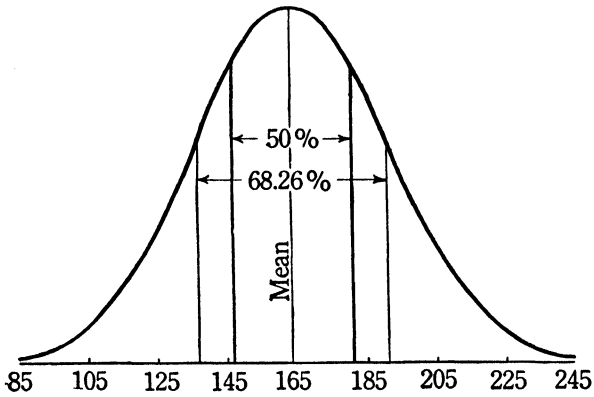


FIG. 3. A THEORETICAL NORMAL FREQUENCY CURVE.

Showing a hypothetical distribution, and the areas measured by the standard deviation (68.26%) and probable error (50%) of the distribution.

is made to control the objects that are measured. In the illustration mentioned above there was no selection of men other than for age. Had males of all ages been chosen there would probably have been a normal curve, but to simplify the discussion only one age-group was considered. With respect to this age-group none of the factors bearing upon the weights of the men were known. The conditions under which the men had been raised, the types of food they had eaten, their inheritance, their occupation, general health and what not, would all help to determine the measures. It is evident that the men in this age-group were taken just as they came; hence there was a chance distribution of measures. Other things being

equal, a chance distribution gives a normal probability curve.

Uses of the Normal Probability Curve. So often is this curve found in psychological measurement that it has been accepted as a standard to which test-scores are made to conform before the tests are used in locating an individual in the group with respect to any particular trait. This procedure, however, is purely arbitrary. Furthermore, the curve is very convenient, for because of its peculiar character several mathematical formulae can be employed which enable us *to predict the position of an individual in the group with respect to the trait measured.* Now, in any given instance, if a relatively large number of measures are closely bunched about the measure of greatest frequency, we will get a curve with a steep slant; measures scattered widely will give a gradual slant. This slant, as well as the most frequent or central measure, is an important characteristic of the curve. In the ideal distribution this most frequent measure, called the *mode,* is also the *average* of the measures and it is likewise the *median* or the middle measure between the smallest and the largest. In most actual distributions these values do not coincide.

The mode, average and median are called measures of *central tendency.* They are values about which the largest numbers of measures cluster. There are other mathematical values which represent the amount of this clustering, or better, the extent of scattering or *deviating of measures from the average and median.* These are called the average deviation, the standard deviation and probable error, all of which will be explained in their turn. Sample problems are found in the appendix.

Measures of Central Tendency. The measures of central tendency which are used most frequently are the average (mean) and the median. The formula for computing the average is

$$A = \frac{\Sigma \text{ Measures}}{n} \qquad (1)$$

which is to be interpreted as follows: The average is equal to the sum of the measures divided by the number of cases.

The median is the middle measure of a series when all the measures are arranged in order of size from lowest to highest or *vice versa*. The formula reads:

$$M = \frac{n+1}{2} \qquad (2)$$

The median falls at a given case when there is an odd number of measures. When there is an even number of cases the median lies between the two middle cases.

In order statistically to locate an individual in the group, with respect to his score in a particular performance, either the average or the median must be known. For rough placing, the method is simply to ascertain the position occupied by a given individual's score in the total range of scores from lowest to highest. By using the *median as a point of reference* it can easily be determined whether a given score falls in the upper or the lower half of the range. Somewhat more precise is the method of dividing the range into four parts, called *quartiles*. Then it can be determined by inspection whether *A's* score is in the first or highest quartile, the second, the third or the fourth. Still more precise is the method of transposing all scores into percentages, calling the highest score one hundred and the lowest, zero. Then a person's score places him with respect to one hundred divisions of the total range instead of four. These divisions are known as *centiles*. It is frequently convenient to group these one hundred divisions into ten parts, or *deciles*, and to rate each individual's score 1, 2, 3, . . . to 10 according to the decile into which it falls. In many of the universities that give intelligence tests to entering freshmen, original scores are converted into decile ratings. An individual is given a rating of 1 if his score is among the highest 10 per cent of the scores, 2 if it is in the next to the highest 10 per cent, and so on.

Measures of Variability or Scatter. For more accurate work other procedures are necessary, *based upon the average as a point of reference*. Here more definite measures of the scattering of scores from the average must be available. Remember that the original distribution of scores was a chance distribution. It might be, therefore, that if the same test was

given to a group over again, discounting the effect of taking the test twice, each subject would obtain a different score. The probable size of this error must be measured. The first step in ascertaining the degree of this chance scattering of scores is to find the average deviation of individual scores from the average. The formula is:

$$\text{A.D.} = \frac{\Sigma D}{N} \qquad (3)$$

(The average deviation equals the sum of (Σ) the individual deviations, disregarding the signs, divided by the number of cases.) After the plus or minus deviation of each score from the average is found, the plus deviations should total to the same amount as the minus deviations.

The next step in measuring scatter is to compute the *standard deviation* (sigma) the formula for which is:

$$\text{S.D. or } \sigma \text{ (sigma)} = \sqrt{\frac{\Sigma D^2}{N}} \qquad (4)$$

(The standard deviation, or sigma, equals the square root of the sum of the deviations squared, divided by the number of cases.) First, square each of the separate deviations, then find the sum of these squares, divide by the number of cases, and extract the square root.

Value of the Standard Deviation. It is often desirable to know whether a certain individual attained as high a score, relatively, in one type of test as he attained in another. Then it is necessary to compare his position in the group with respect to his score in one kind of performance, with his position in the group with respect to his score in another kind of performance. To accomplish this, both sets of scores must be *reduced to common terms* by finding the standard deviation of each set of scores and then expressing the deviation of any individual score from the average as a multiple of the standard deviation. Suppose a certain individual obtained a score of 200 in an intelligence test, which was a deviation of 100 above the average score of the group. The standard deviation for that group, let us say, is 25. We can then express the score as + 4 *sigma*. Suppose this person obtained a score of 80 in

a chemistry test and that it was a deviation of 40 points above the average. Then, assuming for convenience that the standard deviation for the chemistry test is 20, the chemistry score can be expressed as $+2$ *sigma*. Both scores have been reduced to common terms and we know that the person taking the examinations did not receive as good a score relatively in the chemistry test as he obtained in the intelligence test, and that in one test he was exceeded by a certain number of individuals and in another by a certain number.

Definition of the Standard Deviation. To obtain a clearer conception of what a standard deviation means let us return to the normal frequency curve. On the surface inclosed by a normal probability curve a perpendicular may be erected at the point representing the average, and certain other points found along the base line (base line represents the range of scores from lowest to highest) that represent the range of the standard deviation, both plus and minus. If perpendiculars are erected at these points *an area has been inclosed that covers* 68 *per cent of the measures.* Thirty-four per cent of the scores will be plus deviations and will fall between the average and the right hand perpendicular; 34 per cent of the scores will be minus deviations and will fall between the average and the left hand perpendicular. *This range between the perpendiculars* represents the standard deviation (see Figure 3).

The Probable Error. Next come the final measures of scatter, called the probable errors of the distribution and of the mean. The former is computed from the standard deviation by using the formula:

$$PE\,(\text{dis.}) = .6745\,\sigma \tag{5}$$

and the latter by the formula:

$$PE\,(\text{av.}) = \frac{.6745\,\sigma}{\sqrt{N}} \tag{6}$$

The former signifies that particular range of measures, with the average as its mid-point, within which 50 per cent of the measures fall. Upon giving the test again the chances are one to one that a particular score will fall inside or outside of this range. When a particular score is not much larger than

the probable error of the distribution the score is not considered reliable. The latter formula signifies that at another time the chances are one to one of the average falling within the range indicated by the probable error. A score should be several times as large as the probable error of the average.

Correlation. The usefulness of an intelligence test lies in our ability to predict from it the probability of the same individual's success along some other line, such as mastering the subject matter of chemistry, passing a college course or handling a responsible business position. These predictions depend upon a rather elaborate use of the standard deviation in a procedure which has already been mentioned, namely, *correlation.*

When two series of measures correlate well it means that deviations from the average in one series occur in the same person's scores in relatively the same amounts and in the same direction in the other series. The amount of correlation is expressed by a coefficient which varies from — 1 through 0 to + 1. Plus 1 means a perfect positive correlation; — 1 means a perfect negative correlation. In the latter case deviations from the average in one series occur in the same person's scores in relatively the same amounts but in the *opposite* direction from the average in the other series. 0 means that there is no consistent relationship between the deviations from the average in the same person's scores in the two series. Coefficients of correlation between — 1 and + 1 are expressed in decimals such as —.32 and +.65.

The Rank-difference Method of Correlation. One of the simpler but less reliable methods of computing a correlation is the rank-difference method. (Not based upon σ but upon a substitute in the form of a rank-difference.) Suppose a group of individuals took an intelligence test and also a test in chemistry. The first step in the procedure is to rank each individual score in both tests, calling the highest score 1, the next highest 2, the next highest 3 and so on. Then the rankings are arranged in columns so that the two ranks for the same individuals are opposite one another. The second step is to find the differences in the two rank values for each individual. The third step is to square the differences and

to find six times their sum. This gives the numerator of the formula. The fourth step is to square the number of cases and to subtract the whole number 1 from the product, then to multiply the result by the number of cases. This gives the denominator. Finally, the numerator is divided by the denominator and the result is subtracted from the number, 1. The formula reads:

$$\rho = 1 - \frac{6 \Sigma D^2}{N(N^2-1)} \qquad (7)$$

More elaborate procedures of correlation are required in most statistical work in connection with tests, involving the Pearson Product-moment method, the regression equation, partial and multiple correlations.

The Uses and Interpretation of Test Results

Practical Values of Intelligence Tests. (1) In the more progressive school systems where funds are available, research bureaus are maintained with a staff of testers who locate the mentally retarded and accelerated children. The retarded are placed under teachers who are trained to cope with the problem of the atypical child. As a consequence, instruction of regular classes is more efficient. On the one hand, the child who is unable to keep pace with the average of the group claims much of the teacher's attention and delays the progress of the other pupils. On the other hand, if left in a group whose rate of learning is much slower than his, the accelerated child learns habits of laziness and indolence, and interferes with the progress of the class by giving constant disciplinary trouble.

(2) Tests are useful in high schools in giving vocational advice, in helping the student select his course, and in determining the rate at which the student should attempt to advance.

(3) Likewise, in case of college freshmen a decile rating may be used in predicting the student's most probable achievement (providing he studies) in various types of courses, in determining the most advisable study load to carry, in evaluating his excuses for failures, in determining whether he shall

be reinstated after failing, and in helping to determine his fitness for college.

(4) Another important value of an intelligence rating is its aid in bringing to the notice of the instructor, immediately upon entrance to the school, the student who is likely to make an exceptional record either by failing or by excelling. A certain percentage of failures can be avoided by advising the student that unless he works diligently his chances for passing are very slight. Failure on the part of a superior student may be avoided by an early effort to interest him in special lines of work and in independent study; for not infrequently he leaves college with the feeling that the work offered there is too superficial or formal either to meet his needs or to keep him busy.

(5) Tests are also used in special training and industrial schools. A fairly large percentage of boys and girls committed to reform institutions are mentally dull. Indeed, dullness is frequently associated with delinquency. The moron can not distinguish between right and wrong sufficiently to refrain from engaging in petty criminal activities. Hence, measuring the intelligence of the inmates helps in choosing the proper educational program for them, and in giving them sympathetic care and discipline.

(6) Tests are being employed more and more in juvenile courts. Obviously a bright lad of mischievous intentions should be treated differently from a moron offender who lacks a sense of responsibility.

(7) In its preparation of troops for participation in the World War, the United States supplemented its medical and personnel service with a psychological program. Before the armistice was signed a million and a half recruits had been given intelligence tests, the results from which were used in finding and discharging the mentally defective, in classifying men for different branches of the service and in hurriedly selecting men who would make officer and non-commissioned officer material.

(8) In large industrial plants where the labor turnover is sufficient to affect output, tests are frequently given in connection with other efficiency methods, in order to find positions

for which the candidate is mentally qualified. If a job is too difficult on the one hand or too easy and monotonous on the other, the worker becomes dissatisfied, inefficient, and is inclined to leave.

Intelligence and Occupation. The relationship between mental age and occupation has been measured in several investigations, prominent among which was a study of men entering the army from different occupational groups during the World War. Letter ratings A, B, C and D were chosen to indicate different levels of intelligence. The average rating for unskilled laborers was C—, roughly representing a mental age of about 12. The ratings obtained by tradesmen such as horseshoers, bricklayers, painters, bakers, machinists, plumbers, carpenters and the like, averaged C, or slightly lower, indicating a mental age of approximately 13. Foremen, telegraphers and various kinds of clerks, army nurses and bookkeepers averaged around C+, with a median mental age of 15. Dental officers, mechanical draftsmen, accountants, civil engineers and medical officers fell in the B— class with an average mental age of 17. Officers in the engineer corps obtained the highest average rating, A, with the average mental age of 18.5. The mental age standard was set by the Stanford-Binet test in which the highest mental age given is 19, with 16 as the mental age of the average adult.

The following table shows the mean intelligence scores of size of the different occupational groups in a rubber tire plant [4]

TABLE IV
RELATION OF INTELLIGENCE SCORES TO OCCUPATIONAL GROUPS

Laboratory and drafting	147
Factory Council	144
General clerical workers	138
Shipping department	112
Factory committee	108
Foremen	88
Inspectors	86
Finishers and builders	87
Handing out stock	76
Truckers and mixers	47

[4] From Burtt, *Principles of Employment Psychology.* Boston: Houghton Mifflin Co., 1926, 273.

These facts point to the practical value of testing procedures in business. By using methods of this sort critical scores may be found, a score above which means better than a one to one chance of being successful in a certain occupation, provided other factors such as lack of initiative and inadequate personality do not interfere. Conversely, scores below the critical point mean better than a one to one chance of failing.

Tests for So-called Special Aptitudes: Tests of Musical Talent. Aside from intelligence examinations a great many tests for (a) special aptitudes and (b) special training have been devised with the view of ascertaining in advance a subject's fitness for a given vocation.[5] Seashore's tests of so-called musical ability are the most extensive efforts in this direction. His phonographic tests of pitch discrimination, tonal intensity, time, consonance and auditory memory have been widely used, although their value in predicting the musically talented person is definitely limited. Success in music depends upon a large number of factors that still resist measurement. The tests will not select the successful musician although they may possibly help in locating potential failures.

Vocational Aptitude Tests. Gradenwitz, Tramm [6] and others have endeavored to measure the special modes of response required of trolley motormen, such as visual acuity both in bright and dim illumination, color-blindness, steadiness, knowledge of traffic rules, emotional stability under excitement and mechanical 'insight.' Certain of these investigators tested knowledge of traffic rules with miniature cars at imitation street intersections. Lights flashing on and off represented pedestrians and vehicles; when a given set of lights appeared the applicant decided, under pressure for time, who should start first and who had the right of way.

When a battery of these tests was adopted by one company and 25 per cent of the applicants were rejected, it was found that men hired without the aid of the tests had fifty more accidents during the course of a year. Moreover, the

[5] Seashore, Carl, *The Psychology of Musical Talent.* New York: Silver, Burdett and Co., 1919.

[6] Cf. Burtt, *Principles of Employment Psychology,* 205, 255.

time necessary to train the selected group was shortened by 120 hours.[7]

In addition to tests like these numerous special examinations have been devised for the selection of office workers, factory employees, telephone and telegraph operators, although they amount to very little more than standardized examinations of the candidate's knowledge about his trade, and of his mechanical proficiency in it. The following are typical trade-test questions.

For bridge carpenter..(1) How are stringers fastened to the caps?
(2) What do you use for moving timbers?
(3) What kind of a head has a clock builder's adz?

For moulder.....(1) Name two materials used as a binder for floor sand.
(2) What do you use to make the mould for a large bell, without the pattern?
(3) What is the shrinkage of cast iron per foot?

In addition, the applicant's knowledge of his trade is tested with pictures and blue-prints.

Speed as a Factor in Intelligent Behavior. It is a commonplace observation that individuals who achieve the highest scores on intelligence tests or who reach the highest levels of intellectual attainment are the quickest thinkers. This has led to the belief that speed is an important element in intelligence. Accordingly, time limits are placed upon many of the intelligence tests under the assumption that time is a factor in the separation of the bright from the dull. Whether or not speed is to be considered an important feature of intelligent behavior depends entirely upon the definition of intelligence. Of course if intelligence is defined in terms of rapid thinking, speed is an important aspect; on the other hand, speed measures other qualities in the individual aside from brilliance, for example desire to surpass others and enthusiasm for the task. It is reasonable to suppose that a person who is slow under one set

[7] Viteles, M. S., "Research in Selection of Motormen." *J. of Per. Res.*, 1925, Vol. 4, 100–115, 173–199.

of conditions might exhibit greater speed in a different situation. It can not be said, therefore, to what extent speed signifies brilliance and to what extent it depends upon interest in intellectual achievement.

Intelligence Defined in Terms of Actual Performance. Spearman is the outstanding advocate of the theory that intelligence is composed in part of a *general factor,* or capacity, and in part of an indefinite number of *specific factors,* or specific abilities.[8] A hypothesis of this character is open to the objection that it sheds no real light upon the nature of intelligence. Rather, it complicates the problem for it adds unobserved, unexplained factors to be accounted for. Moreover, a verification of the hypothesis is precluded by the purely statistical and indirect nature of the evidence. Through the influence of this theory there has developed a widespread inclination to speak of general intelligence without any definite or direct knowledge about it. For that matter no so-called specific abilities[8] are observable, yet we frequently speak of them as definite entities. When, for example, a person is heard playing a violin the remark is made, What great ability he has! The listener is basing his judgment, however, upon the actual *performance,* upon just what he sees and hears, not upon an unseen and unheard capacity residing within the player.

Accordingly, intelligence is not observed; *specific performances* are observed and the intelligence is *inferred,* often erroneously as an unseen, unheard, directing force residing within the performer. Such an inference is scientifically unwarranted and merely clouds the issue. Intelligence is a term, then, which does not legitimately stand for a capacity of which a person possesses a definite amount; neither does it mean an endowment, a potentiality or latent power. 'Intelligence' refers to goal activities which we observe in ourselves and other persons in novel situations. Aside from their purposiveness these activities always involve the apprehension of relations. These two are their outstanding features expressed, for the present superficially, because a more thoroughgoing discussion of intelligent behavior appears in the next chapter.

[8] Spearman, C., "General Intelligence Objectively Determined and measured." *Amer. J. Psy.,* 1904, Vol. 15, 201–292. Also, *The Abilities of Man.* New York: Macmillan, 1927.

There is another misconception concerning intelligence. Under a given set of conditions, the conditions under which tests are given, an individual accomplishes a certain performance which can be measured. It should not be concluded that the test measures the subject's limit of activity, for *if the conditions under which he takes the test are changed, his performance will inevitably be changed.* According to the conditions that are changed his achievement will be better or worse. From these considerations it should be clear that predictions made on the basis of tests are possible only when conditions do not sufficiently change to cause unexpected variations in the person's behavior. Indeed, the validity of any prediction rests upon the constancy of the conditions under which the predicted event occurs.

The Constancy of Intelligence. To illustrate this point take the case of an alleged feebleminded boy who, at the age of 12, had a mental age of 8. His I.Q. was therefore 67. When he took the intelligence test the first time he was stunted in physical growth and had been leading a very quiet life at home where there had been made no systematic attempt for several years to stimulate further mental development in him. He was then taken to an expert diagnostician who made practically all of the tests of metabolism known at that time to medical science. The boy was placed on a diet, given thyroid treatment, and at the same time placed in the hands of a trained teacher. Within two years he had grown considerably more than could have been expected without medical treatment, and his general physical condition had vastly improved. He was tested again, this time at the age of 14, when his mental age was 12 and his I.Q. was 86. How much of his improvement was ascribable to medical treatment is not certain. But the boy was able to meet *new problem situations* which he had never solved before, demonstrating that his improvement was not the result of mechanical drill.

It often happens, to be sure, that I.Q.'s remain constant over a long period of time, and for this reason the constancy of the I.Q. has been accepted as a general law. *It is a general law only because the conditions under which children develop remain sufficiently constant to produce a steady rate of mental*

growth to the time development ceases. There is little reason for asserting that a child at six, let us say, with an I.Q. of 60, will inevitably have an I.Q. of no more than 60 when twelve or fifteen years of age. The assertion violates a basic principle of science, namely, that any event is a product of its conditions. Thus, the fatalism with which the results of intelligence tests are sometimes interpreted is scientifically unwarranted. While the I.Q.'s of 'feebleminded' children have not been raised to the level of normality, progress along this line has already been made, as the illustration just given has indicated.

Recent Work on the Intelligence of Adopted Children. Several important investigations of the *nature-nurture* problem have been completed within the last few years. One of these is an elaborate study of adopted children which casts serious doubt upon the theory that intelligence is exclusively a hereditary phenomenon.[9]

Important among its results are the following: (1) of 26 children born of feebleminded parents only 4 had I.Q.'s below 70, sometime after adoption. The average I.Q. was 81 which is considerably higher than is to be expected if feebleminded-ness follows the supposed laws of inheritance. In general the mentality of blood parents of adopted children was low, yet the I.Q.'s of such children were equal on the average to the standards for children in general.

(2) Unrelated children raised in the same home came to resemble one another in intelligence.

(3) When siblings (brothers and sisters) were separated in different types of homes, these differences in environment evidently produced greater variations in intelligence than were evident before the separation. Ordinarily the resemblance between intelligence in siblings can be expressed as .50, the *coefficient of heredity.* When siblings were separated but sent to similar homes the effect was a reduction of this coefficient to the range .30 to .37 for sixty-two pairs. When they were sent to homes of dissimilar culture the effect on sixty-three

[9] Freeman, Holzinger, et al., *27th Yearbook of the National Society for the Study of Education.* Part 1, Bloomington, Ill., 1928, 103–218.

pairs was to reduce the coefficient of heredity to the range between .19 and .28.

(4) Early placement in good homes was an important factor in determining the intelligence level of the child. Improvement in intelligence was evidently more dependent upon the type of home than upon age of placement. It was evident, therefore, that an improvement in environment conditioned a definite improvement in intelligence.

Another elaborate study admitted many of the same facts although with considerable reservation.[10] The outstanding conclusions from this study were, (1) that home environment contributed 17 per cent of variance in the I.Q., and that the maximum contribution of the best home environment would be 20 I.Q. points (at least between 10 and 30). (2) The least cultured home might depress the I.Q. of a foster child as much as 20 points. (3) Parental intelligence alone accounted for 35 per cent of the I.Q. variance. (4) Seventy-five to eighty per cent of the I.Q. variance was ascribable to innate and inheritable causes.

The reader should be warned that inheritance can not be sharply distinguished from environment. Efforts to measure the influences of two arbitrarily separated groups of factors are bound to yield artificial figures. To conclude that seventy-five to eighty per cent of an I.Q. is conditioned by inheritance can mean at best that the causes of intelligent behavior have been controlled merely to the extent represented roughly by the figure 20 per cent. Even this interpretation is unsafe, for there is no way of isolating hereditary from environmental causes.

The Problem of Native Intelligence *Versus* Training. There is another misconception about tests, the theory that they measure native endowment rather than education. It is impossible from any angle to separate environmental influences from influences traceable to heredity (see page 491). Intelligence examinations are certainly tests of education to the same extent that they are measures of inherited factors,

[10] "The Relative Influence of Nature and Nurture upon Mental Development. A Comparative Study of Foster-parent Foster-child Resemblance and True-parent True-child Resemblance." Barbara S. Burks, 27th *Year Book*, etc. 219–316.

and very likely to a greater extent. Unquestionably hereditary conditions limit behavior in certain instances, especially in the case of organic defects. Nevertheless, these hereditary factors may eventually be brought under control, at least within limits.

Instead of regarding inheritance as an inevitable cause of physical and mental traits, it is preferable to consider it *as a set of conditions which have not been brought under control, while education represents factors that are under control.* Already, biologists have treated the germ-plasm of the fruit fly with X-rays and have produced mutations, or changed organisms, fifteen hundred times as often as they will appear under undisturbed conditions. The effect of the rays is apparently that of changing the molecular composition of the *genes.* (Genes are certain complex chemical compounds in the germ plasm which are thought to determine the direction of growth in all parts of the organism.) While these experiments do not illustrate the control of intelligence, the *principle* is borne out that inheritance merely signifies an uncontrolled set of conditions. If those factors within the germ-plasm that determine the direction of growth can already be controlled within narrow limits, the near future may witness an environmental control of many so-called inherited forms of behavior. Once the control is effected, the conditions of growth are by definition environmental.

General Conditions of Intelligent Behavior

(1) Inheritance. Methods of measuring intelligent behavior have been studied so far with only a meager knowledge of its conditions. While these conditions are known only in a general way because of their great complexity, nevertheless it will be profitable to consider the problems which are involved in ascertaining them.

While the evidence often advanced to demonstrate the inheritance of intellectual traits points also to environment as the conditioning factor, it may be true that certain conditioning factors are traceable to the individual's ancestry. These factors, however, are hardly more specific than general health,

vitality and the general organization and differentiation of the nervous system.

In 1877, Dugdale reported on the famous Juke family. Max Juke, born in 1720, a man characterized as a shiftless truant, married a woman of evidently low mentality. To 1877 there had been five generations from this union with approximately 1200 descendants among whom there were 310 paupers, 7 murderers, 60 habitual thieves, 50 prostitutes, 130 convicted of crime, 300 who died in infancy and 440 physical wrecks from debauchery. Only 20 of these descendants, it is said, learned a trade, and 10 of them learned it in prison!

Dr. Goddard[11] traced the ancestry of a young girl who had been brought to the Vineland Training School. He found her to be a descendant of a normal father, Martin Kallikak, and a feebleminded mother. Of 480 direct descendants of this mating, found at the time of the study, 143 were feebleminded; there were 292 unknown, 36 illegitimates, 33 prostitutes, 24 alcoholics, 3 epileptics, 82 who died in infancy, 3 criminals, 8 keepers of disreputable houses and 46 'normal' individuals. Martin Kallikak served in the Revolution, and upon his return from the war, married a woman of normal intelligence, from which mating there were 496 direct descendants of whom all were said to be normal with the exception of five, of whom one was apparently feebleminded, two were alcoholics, one a sex pervert and one insane. There were no epileptics or criminals, and only 15 died in infancy. All the others, we are told, were good citizens, including professional men such as doctors, lawyers, educators, judges and business men.

In contrast to these cases the Jonathan Edwards family is often cited which had 1400 direct descendants in about 150 years among whom were 120 graduates of Yale, 14 college presidents, over 100 college professors and many other successful persons.

While all these statistics may point to hereditary conditions of intelligent behavior, *they do not measure the influence of these conditions.* The offspring in question were not removed from the environment in which they were born, and

[11] Goddard, H. H., *The Kallikak Family.* New York: Macmillan, 1913.

subjected to reverse conditions. No one knows what proportion would have then matured normally. Moreover, criminals, prostitutes, physical wrecks from debauchery, drunkards, keepers of gambling dens and disreputable houses, paupers and such like, *are products of society, not of inheritance.* It is misleading, therefore, to consider them as exclusively conditioned by a bad inheritance. It is more likely that inheritance had relatively little to do with these outcomes.

The available evidence leads Goddard to estimate that 65 per cent of feebleminded individuals have inherited the defect. Other investigators report a like figure. But it should not be concluded that if 65 per cent of the feebleminded inherit the defect, 65 per cent of physical and mental traits are inherited. On the contrary, there is no single trait which is not both inherited and acquired, if one is to make a rigid distinction between the two sets of conditions.

(2) Social Status as a Condition of Intelligence. Figures like the following have been offered in proof of inheritance, but they are equally as effective in demonstrating social influences.[12]

TABLE V

RELATION OF INTELLIGENCE RATINGS TO SOCIAL STATUS

Occupational group	Median I. Q. of children in the grades	of children in high school
1. Professional	116	121
2. Business and clerical	107	112
3. Skilled labor	98	108
4. Semiskilled labor	95	108
5. Farmer	91	106
6. Unskilled labor	89	111

(3) Race as a Condition of Intelligence. Here again the social are inseparable from hereditary factors. If intelligence tests, standardized on American whites, were a fair instrument of measuring the intelligence of other races, Indians, Negroes, Italians, Portuguese and so on, would be

[12] Haggerty, M. E., and Nash, H. B., *J. of Educ. Psy.*, Vol. 15, 1924, 559–573.

judged inferior. It is frequently assumed that, because only about 25 per cent of Negroes reach or exceed the average score for white individuals, Negroes would make no better showing if their economic and social status were equivalent to the 'whites.' As it is, the Indian, Negro and other races are inferior to white races only when intelligence is defined in terms of test-scores based on 'white' norms. There is no convincing evidence that one person's so-called intelligence is like another's, or that the intelligence of one race is qualitatively similar to the intelligence of another race. One individual will excel in many lines such as art, literature, business and science, while another individual will exhibit superiority only in one line. So-called intelligence is therefore as inseparable from factors like temperament, interest and ambition as it is from training. Consequently, if intelligence is a thing in itself, it is necessary to concede several intelligences in the same individual.

(4) Physical Condition and Intelligence. Average 'ability' is associated with average health and with a normally *differentiated* nervous system. No striking organic brain defects (although defects undoubtedly exist) have been found in morons, but as the lower stages of feeblemindedness are reached definitely undifferentiated brain conditions can be observed. In the worst cases of imbecility and in nearly all idiots, brains are badly underdeveloped texturally; they may be small in size but not invariably. Occasionally the forehead slants back sharply from the eyebrows, giving to the individual an ape-like appearance. Heads of this contour are called *microcephalic*. *Hydrocephalis* is another abnormal organic condition characterized by an enlarged cranial chamber, caused by excessive amounts of cerebro-spinal fluid in the brain ventricles. This not only increases the size of the head but often presses the brain material into thin layers against the inside of the skull.

There are various glandular defects associated with feeblemindedness. Thyroid and pituitary deficiency, especially, are frequent contributing causes (see page 214). Indeed, as a rule the feebleminded individual is also feeble physically, not only in one but in many respects. He possesses a weak heart,

a lowered metabolism and weak muscles; he breaks down physically under strain. On the other hand, where general physical weakness is associated with intellectual superiority it is a weakness not of nervous and physical organization, but a special abnormality which does not disturb the behavior of the individual as an organic unit. The precocious child is in the long run superior both physically and mentally. This is to be expected, for generally speaking, those conditions which produce excellent physical development also produce a stable, well developed nervous system: conversely, those conditions which produce a defective nervous system bring about a defective set of bodily organs generally.

(5) Emotional Blocking as a Condition of Intelligent Behavior. Emotional blocking hinders the development of intelligence. There are many cases in which the I.Q.'s of children have increased with the elimination of emotional maladjustments. It has been suggested that these children were innately more intelligent than the test indicated, and that removal of the blocking released a potential which had not hitherto expressed itself. But again the inference of a capacity or potential to explain the results of tests is inconsistent with scientific principles. One might as well explain the weight of an object by asserting that it has a capacity to weigh a specific amount, or that a tree grows because of a capacity to grow! Any performance is explained in terms of the conditions under which it takes place. Many of the conditions of intelligent behavior are unknown, to be sure, but to classify these unknown conditions under the term capacity is merely to admit ignorance. (See discussion of instinct, page 168). Emotional blocking is, therefore, a definite condition of intelligence if intelligence is defined as actual performance.

(6) Pacing. Between the extremes of excessive overstimulation and understimulation of the child lies moderate stimulation which if properly controlled leads to a steady, normal development of intelligence. This mode of stimulation may be given the name, *pacing*.[13]

[13] Suggested by Harry Helson.

Its significance can not be understood until later on when the more precise conditions of mental development are discussed (page 313). At present we shall think of pacing as gradually giving the child more and more complex tasks to perform, as he grows and matures. The increase in stimulation and in difficulty of problems should not at any time be faster than the child's rate of maturation, otherwise repeated failures to master the tasks at hand are induced. Too frequent failures lead the child to develop undesirable habits of work and unhealthy emotional attitudes. Once he masters a task of a given difficulty he should not be presented with another and more difficult task until a recess period has elapsed during which he may have time to *grow* to the more difficult situation. *Theoretically* if the degree of stimulation is adequately controlled, *the child should be able perfectly and easily to solve each new problem the first time it is attacked.* When he must resort to 'trial and error' or to a random procedure it is evident that he is not ready for the problem and that the conditions under which he is being forced to learn are not adequately controlled.

(7) Stage of Maturation as a Condition of Intelligent Behavior. *Finally, the evolutionary stage of physical and neural development, either in the race or in the individual, is a condition of intelligent behavior. This condition will be discussed at length in the next chapter.*

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CHAPTER V

INTELLIGENT BEHAVIOR: DIRECT METHODS

The Origin and Development of Intelligent Behavior in Animals

Introduction. The development of behavior from the simplest animals to man is so gradual that the exact origin of any particular type of response is indeterminate. Moreover, at the outset the perplexing question arises of identifying intelligent behavior in animals. Earlier writers argued that when an organism showed signs of forming associations, that is, of learning from experience, it was exhibiting the beginnings of intelligent behavior. This assumption led to others which were necessary to explain the mechanisms of learning by experience. Accordingly, Thorndike offered the theory that satisfaction and annoyance, or their equivalents, caused the animal to learn certain habits and prevented it from learning others. Pleasure and pain thus became *agents of accommodation.* For example, a young chick when first hatched pecks at various objects. It derives a pleasant taste from certain edible objects and associates the pleasantness with the object; it associates unpleasant experiences with inedible objects, and as a consequence it inhibits the impulse to peck the latter and establishes the habit of pecking only at the former. But, the criterion, learning by experience, proved unsatisfactory because it assumed experiences whose presence in the animal was uncertain. A working hypothesis less implicative of human types of response, or less *anthropomorphic,* was therefore adopted by most animal experimentalists, namely, the modifiability of behavior.

Tropism as the Beginning of Intelligent Behavior (?) The origin of intelligence can be comprehended only after an

examination is made of behavior in the lower organisms. Loeb,[1] a prominent investigator in animal behavior, did not ascribe intelligence to the lower organisms; in fact he interpreted their responses mechanistically and characterized many activities in higher forms of life in the same way. Certain lower animals, for instance, are attracted or repelled by light; their orientation follows the same laws that govern the bending of plants toward light rays. Other animal reactions such as orientation to chemical substances, to gravity, to electrical potentials and to temperature are of a similar nature according to Loeb, who employed the name *tropism* to describe them. He explained these tropisms in terms of specific irritability at the surface of the animal, and in terms of body symmetry. Symmetrical elements at the surface possess the same irritability; unsymmetrical elements show a different irritability, and the anterior part of the organism reveals a greater sensitivity than the posterior part. These circumstances *compel* the animal to orient itself in such a way that symmetrical points on the surface are stimulated equally. Hence the animal is led mechanically toward the source of the stimulus or mechanically away from it, head end first.

Suppose a worm is near a particle of food. Stimuli originating in the food in the form of gases impinge upon the body on one side and cause the muscles to contract more strongly than on the other side. As a consequence the worm *is turned* toward the food until it is facing the object and both sides of its body are receiving equal stimulation. According to this theory, also, the moth which flies toward an arclight is not drawn by curiosity or from any conscious motive, but is likewise compelled to orient its body so that symmetrical points receive equal amounts of stimulation. With this type of explanation as a starting point it was an easy matter on first thought to imagine how complex behavior might be explained as combination of tropisms. Jennings, however, opposed the tropism theory because of insufficient evidence and because it was obviously too simple to account for the *variability* of the organism's behavior. Jennings points out that paramecia (tiny, one-celled water animals) will gather in

[1] Loeb, J., *The Mechanistic Conception of Life.* Uni. of Chicago, 1912.

weak acid but they do not align themselves with the currents of acid diffusing through the water. This fact indicates that they are not compelled to swim into the chemical but rather that, once they enter it by chance they remain there. Moreover, the emphasis upon external stimuli as the conditioning agencies neglects the fact that the organism-as-a-whole contributes to the performance. While Loeb recognized the organism-as-a-whole, it is doubtful whether he appreciated the logical force of the implication that the organism is *drawn* or *attracted* to the stimulus.

Intelligent Behavior Not a Development From Tropisms. Are tropisms the beginnings of intelligent behavior? Hardly, unless the latter is to be considered a mechanical response which is the exclusive means of forcing the organism to orient itself to its environment. Intelligent behavior, as the evidence will show, is the opposite in that the organism becomes an *active participant in the total stimulus-situation.* There is one suggestive clue, however, in regard to the origin of intelligence which can be derived from Loeb's discussion of tropisms. Unequal stimulation on different parts of a simple organism produces an unequal tension which is balanced by the execution of movements. A 'tropism,' therefore, is a response in *the line of least action* the end of which is the *establishment of an equilibrium.* When the organism's position with respect to the stimulus-situation is such that the forces acting upon it are balanced with forces within it, equilibrium is reached.

Intelligent Behavior Defined in Its Beginnings. The working hypothesis may be offered that the antecedents of intelligent behavior are not found in a *mechanically* defined tropism but in an activity which *demands its own termination* in the resolution of a tension. The animal's behavior is not a mechanical performance, because external and internal conditions alike are controlling it; that is to say *a total system of forces of which the organism is a member is giving direction to the activity.* As a consequence, the organism modifies its own behavior with respect to a goal, the goal being the point at which the tension is resolved. In the light of this definition the antecedents of intelligent behavior are found

in the simplest animals such as the paramecium, for this animal will modify its own behavior.

Day and Bentley on Paramecium. The paramecium is constantly active and swims about by means of numerous cilia on the surface of its body. If it comes into contact with an obstruction it will back, turn at a slight angle and dart forward again. If it then hits the obstruction it will back a second time, dart forward again and repeat the process until it has turned itself at a sufficient angle to swim past the object. Day and Bentley [2] confined the paramecium in a closed capillary tube where there was insufficient room to turn around. The animal commenced at once to collide with the obstruction at one end of the tube. After a while it reversed its cilia and swam to the other end of the tube where it bumped the obstruction repeatedly, *but not as many times as before.* Then it reversed its direction again and continued the process at the other end of the tube. As the experiment progressed the reversals occurred more frequently as shown in Figure 4.

After the paramecium had reversed its movements seventy-five times the experimenters allowed it to swim about freely in a cover glass. Figure 4 also shows the animal's performance after it was returned to the tube. The modified behavior persisted! In explaining these results we may suppose that constant hitting against the obstruction produced a rising tension or irritability within the organism, which it removed by reversing the direction of its swimming movements. The paramecium contributed a modified performance which resulted *in the resolution of a tension.*

Yerkes and Huggins on Crawfish. Turning to typical studies of animals somewhat higher in the evolutionary scale, an experiment by Yerkes and Huggins [3] on the crawfish may be taken as an illustration. Their apparatus consisted of the simple maze represented in Figure 5. *S* is the starting point where they placed the crawfish; *P* is a partition and *G* a glass obstruction; *O* is an open path to the aquarium and food.

[2] Day, L. M. and Bentley, M. A., "A Note on Learning in Paramecium." *J. of Anim. Beh.*, 1911, Vol. 1, 67–73.

[3] Yerkes and Huggins, *Psy. Rev. Mon. Suppl.*, No. 17 (Harvard Studies I), 1903, 565–577.

The positions of *G* and *O* could be reversed systematically to prevent the animal from acquiring a place or direction habit.

The object of the experiment was to ascertain how rapidly the crawfish could learn to choose the open path, whatever the latter's position. Figure 6 shows its rate of learning. During the first ten trials it made no more successful choices than would be expected by chance; in the second ten trials

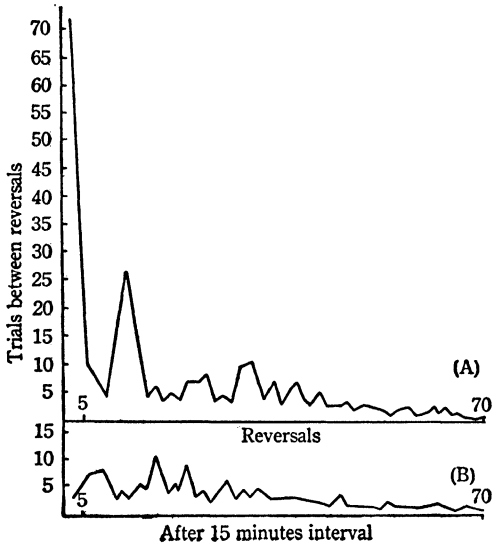


FIG. 4. LEARNING CURVE OF A PARAMECIUM (Day and Bentley).

The numbers of times the animal bumped an obstruction before reversing its direction of movement are plotted against the number of the reversal. Thus, between the first and second reversal (Curve A) there were over 70 trials or 'bumps.' By the time the 70th reversal had been made the bumps between reversals were less than 5. Curve B shows the animal's performance after a 15-minute interval following the first experiment.

it made 60 per cent correct choices; finally, it was making a score of 90 per cent. Then, after a recess of two weeks it made a score of 70 per cent correct responses.

Here the assumption is plausible that the animal's movements were efforts to resolve tensions resulting from a strange situation. When confronted by the glass obstruction its tensions increased, and it kept moving until it found the open path. Moreover, it gradually reacted to the open path in

its relation to the total situation including the glass barrier, maze and aquarium beyond. The crawfish did not reason that it should take the open path because that path led to the aquarium; neither were its movements toward the open path learned because they were associated with the pleasure of entering the aquarium. It can not be said that the crawfish experienced pleasure, but it is not unreasonable to assume that this behavior was directed by a goal or end, sensed in a simple way in its relationship to the total situation.

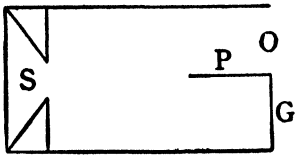


FIG. 5. BOX FOR STUDYING LEARNING IN THE CRAWFISH (Yerkes and Huggins).

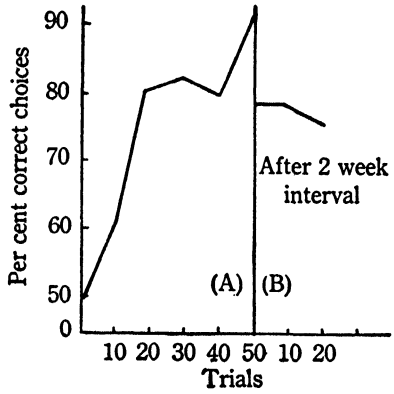


FIG. 6. LEARNING CURVE OF A CRAWFISH (Yerkes and Huggins).

Wheeler and Perkins on Goldfish. Following the work of Révész, Köhler and others on higher organisms, Wheeler and Perkins experimented on goldfish with the view of discovering if animals of this relatively low order would respond to one stimulus in its relationship to others in the total situation. The experimental setting consisted of an aquarium in which were placed three lighted compartments containing food (Figure 7). A fish was gently dropped into the 'pen' in front of the compartments. Certain fish were taught to feed from the brightest, some from the darkest and some from the compartment of middle or moderate brightness. After each entry to a compartment the positions of the lights were changed. In a short time the fish (42 in all) learned to enter the correct compartment whatever its position. Then, in a

test experiment the lights were 'stepped down.' What had been the right compartment now became a wrong one, and yet the fish made correct choices in nearly every instance. When all the lights were 'stepped up' in brightness so that the dimmest light was as bright or brighter than the strongest of the original combination, the fish continued to make correct choices. These results indicate that whatever the combination of three lights, the fish were able to choose not only a light of given absolute intensity, but also one of *relative intensity*. Occasionally the dimmest compartment of the three contained no light and yet the fish chose it in preference to the compartment of absolute intensity into which they had originally gone. Similarly, although the intensities of all three lights were subsequently made several times as great as the original intensities, fish taught to choose the brightest light still responded correctly. The goldfish evidently reacts, therefore, to one detail of a situation in its relationship to other details, for it almost perfectly makes a transfer from one combination of lights to another.

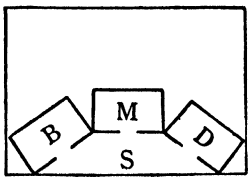


FIG. 7. PLAN OF APPARATUS IN EXPERIMENT ON DISCRIMINATION IN THE GOLDFISH (Wheeler and Perkins).

B, *M* and *D* signify bright, medium and dim lights. *S* is the position in which the fish was placed at the beginning of each experiment. The positions of the lights were changed after each entry into a compartment.

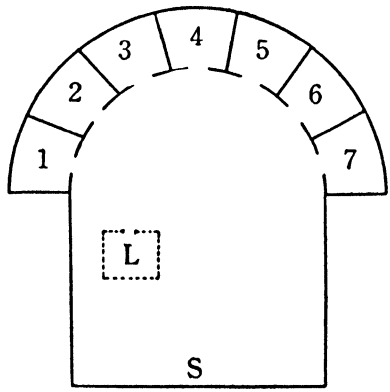


FIG. 8. PLAN OF APPARATUS FOR STUDY OF DISCRIMINATION IN THE CHICK (Lewis).

1 to 7 are lighted compartments. *L* shows the position of an extra light introduced into the experiment. See explanation in text. *S* is the position from which the chick started each time. (From an article to appear in the Journal of Experimental Psychology.)

Lewis' Experiment on Chicks. Working with chickens, Lewis continued this type of experiment still further. He found that certain subjects were able to locate the dimmest of seven lights arranged in a semicircle, others the brightest of seven lights, and still others the middle intensity of five lights. After the correct light had been learned, if it was placed in a box in the center of the space in front of the semicircle (Figure 8) the chicks chose it with surprisingly few errors. Then, with a new group of chicks Lewis shifted the intensity of the lights as well as their position after each trial, and discovered that the learning process took place even more rapidly than before. From the outset these latter chicks unquestionably learned to recognize *relative* brightness because the brightness was constantly changing. The conclusion is inevitable that they perceived each light in its relationship to the others; they perceived a *constant relation,* or what a human being would call a principle.[4]

Helson's Experiment on Rats. Helson[5] had previously shown that the white rat learned simple problems of this type very rapidly. After the learning process was complete he changed the absolute intensities of the lights without changing their relationships and still his animals responded correctly. In two of Helson's rats interesting behavior occurred when he used gray papers of different brightness in front of two adjacent food boxes. To teach his subjects that a particular gray was the cue to the compartment from which they were to obtain their food he punished them with a mild electric shock if they chose the compartment labeled by the other gray. The path to each compartment led over an electric grill which was charged when in front of the wrong box and not charged when in front of the right one. After being shocked a few times his rats showed fear even of the dead grill. One of his rats had just entered the wrong compartment and had been shocked when, instead of returning across the grill as it had done nine times before, it climbed over the partition into the food box on the other side. Another rat

[4] Wheeler and Perkins have recently found that goldfish behave in a similar fashion with reference to three lights.

[5] Helson, H., "Insight in the White Rat," *J. Exper. Psy.*, 1927, Vol. 10, 378.

behaved in essentially the same way. *Both had taken the shortest possible route to the food in avoiding the shock.*[6]

The Preceding Experimental Results Interpreted. The directional behavior or goal-activity of animals like the fish and rat is more complicated than might be supposed. The *first* feature of this behavior is an act of seeing or of otherwise perceiving a goal in its relation to the whole stimulus-situation. This feature is indicated by the fact that changing the physical properties of the goal without changing its relationship to the total situation failed to inhibit the animal's response. Of course the tension which the animal resolved through its behavior was a hunger tension and the goal was food, but it was food-in-a-certain-compartment. The animal's goal-activity involved seeing a certain type of stimulus (a lighted doorway) in its relation to food. The precise fashion in which one doorway rather than another came to function as a goal will be discussed later (page 317). The *second* feature of the animal's adjustment was the making of movements that carried him to the goal.

The question arises at once, how did it happen that these movements were co-ordinated toward the goal? The existence of a goal implies tension in the animal and co-ordinated behavior toward the goal. Recall the simple gravitation system in which the center of the system is an essential factor in determining the direction of a falling body. Likewise in animal behavior, the position of the goal is an essential factor in effecting the co-ordination of the animal's movements. But this is not all; just as the alignment of stresses surrounding the falling body also conditions its path, so, other stimuli aside from the goal play a part in directing the organism's movements. The same situation, described from the standpoint of the animal, was depicted in the preceding paragraph when we said that the animal perceived the goal in its relation to the total stimulus-pattern. In any configurational system, then, an alignment of high stresses in one set of positions and a low stress in another position determine the path of a body moving within that system. The system as a whole con-

[6] Helson suggests that this behavior follows the law of least action. See his article, *loc. cit.*, 388.

trols the movements of its parts. Similarly, the animal is moving within a configuration of forces or stimuli that are acting upon it. These forces elicit movements in the direction of the goal or the position of lowest stress within the configuration, or in other words, in the direction in which the animal's tension is resolved. The configuration in which the animal moves directs the animal in the line of least action. All this means that once the goal is established the movements of the animal toward it are co-ordinated, for 'co-ordinated' means *directed toward an end.*

This is only part of the story! The animal is a member of the configuration in which it moves, and unless the animal perceives the goal in the stimulus-pattern as a whole, the goal is not established. The perception is part of the configuration of stresses that is bearing the organism to the goal. Thus when an animal is confronted by a strange situation for the first time in which a goal is offered and perceived, new and appropriate responses are made, already organized with respect to the goal. In referring to this organized response at the level of conscious behavior we shall use the term *insight.*[7] Insight is not an explanatory concept; it is purely descriptive. The perception of a goal in relationships which have not been encountered previously may be taken as a criterion of insight. Since any particular goal, for example food, never presents itself *twice* in exactly the same configuration of stimuli, any perception of a goal involves new features of response and can, therefore, be considered a criterion of insight.

Further evolution of organized response confirms the theory that has just been presented. Let us consider the evidence as it appears in the behavior of apes.

Köhler's Work With Apes. Köhler[7] performed numerous experiments upon chimpanzees, leaving no question but that these higher animals respond to one stimulus in its relation to another to the extent of *using an object as a tool.* In one experiment Köhler placed a banana outside the ape's

[7] Köhler, W., *The Mentality of Apes.* (E. Winter, Tr.) London: Kegan, Paul, 1924. Quoted by Koffka, K., *The Growth of the Mind.* New York: Harcourt, Brace, 1924.

cage with a string attached to it, the latter within the animal's reach. All the animals were able without hesitation to draw in the banana by means of the string. But a dog, placed in a similar situation, failed to take any notice of the string which lay directly beneath its nose! In another experiment Köhler placed the banana outside of the cage beyond the ape's reach and laid a stick on the floor within the cage. If this stick was so placed that it was not visible when the ape's gaze was upon the fruit, the problem proved to be too difficult. But when the ape saw the stick at the same time that he saw the banana he apparently perceived it in its relationship to the goal, for without hesitation he used it as a means of securing the banana.

Again, the experimenter suspended the food above the ape's reach and left a box nearby. One of his subjects, Koko, apparently solved this problem of relationship. At first the ape sprang at the fruit without success. At a moment when he happened to be away from the wall on which the fruit was hung he approached the box, glanced across to the fruit and gave the box a push, but it did not move. Then his movements became slower; he took a few steps away from the box and then returned to it, after glancing again at the fruit. During a third attempt he succeeded in moving the box about ten centimeters. Then Köhler made the goal more attractive by adding a piece of orange to it. A few minutes later Koko returned to the box and grasped it suddenly, pushing it in one movement almost directly under the goal. Then an interesting thing happened; when Köhler hung the goal upon another wall the ape failed to solve the problem and did not succeed until after an interval of several days, when the test was renewed. This time the ape was successful and continued to be successful thereafter.

Chica, another ape, exhibited a striking performance which throws additional light upon intelligent behavior. In one test she strove repeatedly to reach the suspended fruit without using a box which stood in the middle of the room, although she had already employed boxes in similar tests. The box was not being overlooked for repeatedly she would squat upon it when out of breath. During the whole time, another ape,

Tercera, was lying on the box. Later, when Tercera happened to fall off, Chica grasped the box, immediately dragged it under the fruit, mounted it, and reached the goal. Evidently, according to Köhler, *the-box-which-Tercera-was-lying-on* was not an "object with which to fetch the goal" but "something upon which to lie." As long as the box appeared to the ape in one set of relationships it did not possess any other relationships at that particular time.

In another series of experiments Köhler constructed four hollow sticks of different diameters. Number 1 fitted into 2, 2 into 3, and 3 into 4. When compared with 1, 2 was thicker, but it was thinner when compared with 3. His apes learned to fit the smaller end of one stick into the larger end of the other. During practice with two sticks they held the thicker one passively in the left hand and moved the thinner one toward it with the right. With four sticks instead of two, two given him at a time, Sultan grasped the thinner tube at once with the left hand and the thicker with the right in eight trials out of twelve, but in the remaining four trials he changed the sticks about before he made any attempt to fit one into the other. In other words, he picked up stick number 2 with the left or with the right hand *according as it was to be fitted with number* 1 *or with number* 3*!*

Two Stages in the Development of Intelligent Behavior. Thus far two important stages have been observed in the development of intelligent behavior, the second of which is but an elaboration of the first. The first is a response to one detail of a situation in its relationship to other details, and this type of response begins as far down in the animal scale as the fish and presumably lower. An illustration was found in the behavior of the goldfish which evidently perceived the intensity of one light in relationship with the intensities of other lights. The second stage is found when one detail of a situation is perceived in a more complicated relationship to the total situation, namely, *the relationship of means to an end.* It need not be implied that Köhler's apes thought or reasoned like human beings; they probably did not classify their reactions as they made them. They defined a string, a box or a stick as a tool *merely by using it in arriv-*

ing at the goal. It is unnecessary to assume a human type of imagination in which the consequence of employing a tool is explicitly noted before the result is obtained. The object is recognized implicitly by proceeding to use it without *discrete steps* in thinking. Both stages of intelligent behavior are *directional* in character, as can be seen from the fact that one detail of the situation to which the animal is responding functions as an end or goal. Moreover, the response follows the line of least action; the stimulus-situation produces tensions; the end of the response is a resolution of these tensions into a state approaching an equilibrium.

That is to say, the ape, as an example, is a vastly complex system of stresses existing in the structural form of nerves and muscles which, once a goal is perceived, co-ordinate in such a way that the animal moves over the most direct temporal route toward the goal. The ape's use of an available tool in order to secure food beyond reach is obviously a more direct procedure than hunting for openings between the bars of the cage through which to squeeze himself. A recourse to hunting, however, might illustrate the law of least action if no tool were perceived in relation to the goal. Thus, what constitutes the most direct path toward the goal depends upon the configuration in which the goal is perceived, and the so-called wasted movements made by the animal are the results of several goals functioning in configurations that do not constitute a well-unified whole. The separate responses carried out with respect to relatively independent goals will then follow their own lines of least action. To illustrate, the ape might see the food beyond reach and extend his arm toward it, without avail; then he might notice the stick on the floor of the cage, run to it, pick it up and drop it. Here the stick was for the moment a goal independent of the food. It is implied, therefore, that the perception of the stick as a tool establishes the series of movements directly toward the fruit, while the precision of the movements corresponds to the completeness of the ape's insight into the total situation.

So-called Instinctive Activity as Intelligent Behavior. Presumably an activity like nest building in birds, often regarded as instinctive, involves the simple insight of seeing

objects as tools. So too, a hound exhibits simple insight in following the scent of a rabbit; the dog smells the scent in its relationship to the total situation as something-to-be-followed. Of course in the lower animals, in birds, and in the insects, behavior is highly specialized because of a neuromuscular system that is highly developed along specific lines. Consequently responding to objects-in-relation is definitely limited to particular classes of objects and to restricted classes of relations. In any case, however, where the term instinct was formerly used, the phrase intelligent behavior is more appropriate (cf. page 171).

The Evolution of Intelligent Behavior in Primates

The history of intelligent behavior from the ape to man is essentially the story of an increase in the *use of tools in arriving at goals.* The goals themselves become more varied, more numerous, and spatially and temporally more remote from the immediate activities of the organism. Likewise, tools become more varied and numerous. Whereas, the early stages of man's evolution from ape-like forms are clouded with uncertainty, within the last half century much progress has been made in filling in the missing links.

As we commence with prehistoric man we already find intelligent behavior evolved to the extent that tools are used in simple situations. The earliest forms of man not only used objects as tools in the simplest situations, but used pieces of fallen limbs and stones in self-protection and in order to kill animals for food. They may have thrown these objects at their prey or at an attacking beast, although this latter procedure is a distinct and important step in advance over the use of a tool in the hand. Definite evidence of another important advancement is to be found in certain early implements called *eoliths.* These eoliths were flints and stones *very roughly chipped and shaped for holding in the hand,* and were undoubtedly used as hand axes.

Pithecanthropus Erectus. In very early geological strata a piece of skull, some teeth and a thigh bone have been

found which apparently belonged to the creature who used these eoliths, and from these few clues his supposed form has been reconstructed. He was named *Pithecanthropus erectus,* the walking ape-man; his date is most likely some 500,000 years ago.

Neanderthal Man. Geological strata of later periods reveal an increasing number of implements but no bones from which to construct their users. Scrapers, knives, darts, stones for throwing, hand axes and even borers have been identified by archaeologists. Subhuman creatures had taken to living in caves for protection both against climate and enemies and left implements there, and finally, some of their bones. If the story told by numerous skulls and bones is true, around 50,000 years ago there lived a race of men named *Homo Neanderthalensis* who fashioned many stone implements, called *paleoliths.* Some investigators believe that they used a variety of wooden implements as well, and had learned the use of fire made with flint and rock. They wandered about over large areas and established 'squatting places' near a water supply.

The Cro-Magnons and Grimaldis. Neanderthal man lived over a long period of time, possibly 200,000 years. Then came a glacial period after which (40,000–25,000 years B.C.) a more advanced human type emerges, which, according to Osborn,[8] exterminated *Homo Neanderthalensis.* These primitive men must have developed parallel with the *Neanderthal* race but we know little or nothing about their origin. They had already differentiated into at least two races, the Cro-Magnons and Grimaldis. They were like savages as we think of the latter today, although they had not as yet domesticated any animals unless it was the horse. They drew and painted on the walls of caves, on bones and antlers, and they carved small figures. They buried their dead, evidently with ceremony. They had not developed elaborate processes of thinking, for their drawings depicted only men and animals. They had little if any powers of abstraction as we think of abstraction; at any rate they left no traces of a definite religion, and evidently had no superstitions. Yet they were emotional to

[8] Osborn, H. F., *Men of the Old Stone Age.* New York: Scribner, 1923.

some extent; there was fear of the father and love for the mother, and probably a limited and primitive language of gesture and articulate sounds.

From Cro-Magnon to Present Day Savagery. From this time on, advancement in intelligent behavior can be described only with reference to certain outstanding events, like the invention of pottery and weaving, the domestication of animals, the development of primitive agriculture and housebuilding, the invention of number, the origin of primitive religion, traditions, complicated social organizations and *written language.* Along with skill in making and polishing implements, art, hunting, building houses, securing and saving food and the like, there developed in man's behavior a self-restraint conditioned by numerous social taboos and fears of the unknown. With an increasing freedom made possible by his greater insight there evolved an increasing limitation of the individual's behavior, a limitation made necessary by group life. Hence the evolution of emotive and social behavior now parallels that of intelligence. Indeed, there is no question but that the evolution of intelligent behavior from this time on is essentially a social phenomenon.

The early history of human thought is, therefore, not only a history of inventions but a history of a life of feeling and social attitude that is ever becoming more and more complex. Group life was to aid the emergence of religious beliefs by the relationship it furnished between the 'Old man' and the numbers which he dominated (see page 194). It conditioned a tremendously accelerated growth of ideas when the inventions of superior individuals could be taken over by all members of the group, a factor in the evolution of intelligence which was only accentuated by the migrations and intermingling of races. Witness the tremendous advance of human culture in the last 8000 years as compared with the 500,000 years or more since *Pithecanthropus* and even the 50,000 since *Neanderthalensis.* As early as five or six thousand years B.C. there were definite civilizations; people lived in cities! Over the centuries, language, art, agriculture and commerce developed as *means to ends,* as tools in arriving at goals.

The Origin of Language. Almost nothing is known of the origin of spoken language, but there are numerous factors which may have been responsible for it. Animals utter various sounds when frightened, hurt or mating. From these cries, roars, grunts, groans or other emotional utterances there may have been certain sounds which took on a definite significance in human social intercourse and were repeatedly sounded as warnings, as distress cries and as added features of combat. This is the *emotional theory* of language. Other spoken words like buzz and hiss, which resemble the noises of different animals and various natural sounds, may have been used in referring to the sounds. This is called the *onomatopoetic theory* of language.

Probably many words had more of an accidental origin. To consider a hypothetical example, suppose a member of a prehistoric group was gnawing on a bone when another member attempted to snatch it from him. Under the excitement of the moment the owner of the bone makes a rush at the offender with an utterance which sounds like *katcha,* but it might have been *bada* or *hooyee.* The offender retreats with a bruise on his shoulder. Since *katcha* was part of the total situation to which the would-be thief responded, thereafter not only a threatening individual but one who is fighting and saying *katcha* is to be avoided; finally one who is merely saying *katcha* is to be avoided. Depending upon circumstances, *katcha* acquires the meaning of one who fights, of the bone that yielded the blow, or of the gesture of pretending to fight.

The majority of articulate sounds made by civilized man originated *after the invention of written language.* Moreover, for a long time in the early history of language gesture was more important than articulate sound. Hence the main conditions of sound-language were, (1) gestures and (2) written language, to which should be added (3) *the structural evolution of delicate organs of speech.*

Written language had its evident beginnings in pictures or pictograms. At first the pictures represented objects or situations only if drawn in considerable detail, but with further evolution of intelligence these figures were greatly abridged and elaborated in their finer details to symbolize

more than one object. The alphabet developed from pictograms through the intermediate stage of cuneiform writing in which drawn symbols stood for syllables. The alphabet is credited to the Phoenicians who discovered that pictures could represent sounds as well as objects and situations. This discovery was a remarkable advance over the effort to represent objects with pictures. But the alphabet created by the Phoenicians had no vowels; it remained for the Greeks to invent them later on.

Later Developments in Intelligent Behavior. The development of language was both a cause and an effect of thinking. We know that man had not carried his abstract thinking very far before language developed, and that since then thinking has evolved by leaps and bounds along with language. We know also that language is used to a great extent in the process of thinking, even in thinking to ourselves (see page 433). Meanwhile other symptoms of intelligent behavior were exhibited in the evolution of man. He showed evidence of fantasy and dreaming and of remembering events of the past. He congregated about the fire and listened to stories by the tribal leader or by some wandering adventurer. He wrote down accounts of his visions and of his exploits and developed a literature of poetry and legend.

Evolution of Intelligent Behavior in the Individual

The next problem is to consider the development of intelligent behavior in the individual. This procedure will lead gradually to an analysis of the most complicated of all types of intelligent response, namely, thinking in the normal, human, civilized adult. The infant's behavior like animal behavior reveals the rudiments of intelligence, *first,* in that it involves responding to objects in simple relations and *second,* in its directional character. Since examples of intelligent infant behavior have already been analyzed under personality (page 39 ff), the present discussion begins with behavior from the first and second year on.

Examples of Intelligent Behavior During the Second Year of Childhood. At the age of sixteen months the

author's daughter, Lois, had acquired a vocabulary of 101 words by actual count, 54 of which she had learned of her own accord. Like all children she employed many of them in more than one situation. For example, she responded with *beebe* (baby) to her dolls, to herself in a mirror, to other children and occasionally to adults. She frequently said, Hello baby, to adults, especially as they passed her on the street, for that is what everyone said to her. On one occasion she called a statue a baby.

One of the interesting features of children's early use of words is the *appropriateness with which they apply them to new situations.* There could be no plainer evidence that children learn words and understand them at the outset with reference to a total situation. This situation is at first fairly general, as shown by the selection of the same words to denote several objects of the same class, a selection which indicates a lack of analysis, however, rather than an ability to observe similarities. In other words, it is easier to grasp a total situation unanalytically than to make differentiations.

A second interesting feature of intelligent behavior in children is the *sudden appearance of phrases and sentences.* Children employ in phrases individual words that they have not previously used. For example, at the age of fourteen months, Lois was lying on the bed one day and said, Where's the baby? as she grasped a powder-can on which there was a picture of a baby. Her father had asked her the same question several days previously, but she did not repeat it then *and had not repeated it in the meantime.* Neither had she used, singly, the separate words of the phrase. On another occasion, at sixteen months, she dropped a toy into the soap water of the bath tub. As the toy disappeared from sight, she said entirely of her own accord, There it goes. The occasion, earlier, when her father had said in her presence, There it goes, was a different situation and Lois herself did not repeat the words then, nor had she used them meanwhile, either separately or as a phrase, until the *appropriate occasion arose.* Plainly the acquisition of language is replete with inventions, *new responses made correctly the first time.* Obviously before children adopt a considerable percentage of

their words and phrases they hear them in particular situations, but they perceive them originally in relation to the circumstances under which they are used. It is also clear that from the very beginning children *invent as many phrases as they imitate.*

The Behavior of Children from Three to Twelve. The Stanford revision of the Binet scale includes in its three year old tests, pointing to one's nose, eyes, mouth and hair, and naming familiar objects like a key, penny, knife, watch and pencil. The child names at least three objects in a picture, like cat, table and woman, but generally will not notice action in the picture. At the four year level the child is tested for his grasp of simple spatial relations. He is asked to judge which of two lines is the longer, and to discriminate between forms on the order of a circle and a square. He is supposed to answer questions pertaining to the simple situations: What must you do when you are sleepy? or What must you do when you are cold. His control of arm movements is sufficiently delicate by this time to permit a rough drawing of a square from copy. At five years of age the child is able to make more elaborate discriminations and abstractions. He compares weights of three and fifteen grams, telling which is the heavier although both look alike. He knows the more common colors and judges the prettier of two pictures one of which is obviously ugly. He defines objects like a chair, a horse and a fork in terms of use. By the age of seven he abstracts from a picture the action that is portrayed; and he knows differences between such objects as a stone and an egg, or wood and glass, well enough to express them in language.

Definite signs of adult modes of reasoning appear at the age of eight. The child is then given the problem of finding an imaginary ball lost in an imaginary field, and he draws the path which he would follow in hunting for the ball, revealing a simple plan of procedure. He abstracts sufficiently to explain how wood and coal are *alike,* or an apple and a peach; hence he defines objects other than in terms of use; he classifies them. At ten his comprehension of abstract relations is sufficiently developed to permit apprehending the absurdity

of a statement like the following: I know a road from my house to the city which is down hill all the way to the city and down hill all the way back home. He understands what he should do when his opinion is asked about a person with whom he is not acquainted, and when someone strikes him unintentionally. At twelve his ability to abstract has reached a fairly advanced stage; he knows the meaning of words like pity, revenge and charity; he adopts a systematic plan in hunting for a lost ball; he assembles dissected sentences and comprehends the moral of a fairy tale. When shown a picture he notes not only the action involved but interprets the picture in terms of life situations. Finally, he recognizes similarities in widely different objects as a book, a teacher and a newspaper, or a rose, a potato and a tree.

By the time the child has reached adulthood his intelligent behavior has become so highly differentiated, the possibilities of abstraction have become so numerous and far reaching and the use of language and other symbols is now so extensive that a complete inventory of his activities is virtually impossible. One striking fact emerges, however, that it becomes increasingly difficult adequately to describe his intelligent behavior in terms of overt performances, and more and more necessary to abstract from it features which are observable only through self-observation. This is because in its later stages of development intelligent behavior becomes relatively more and more a use of language and other symbols.

Intelligent Behavior in the Adult

Types of Intelligent Behavior as Observed Through Introspection. Self-observation of intelligent behavior leads to the following abstractions which conveniently classify the higher intellectual activities according to their complexity. (1) In responding to a single object as a whole without explicitly noting its relationship to the total situation, self-observation discloses an activity called *perceiving*. That is, the mental process of perceiving is defined as the awareness of an object as a whole. (2) When the relationship of this object to the total situation is explicitly noted the activity is called

recognizing; the object is labeled or localized with respect to the total situation in which the individual finds himself. For example, if a person responds to an apple and forthwith picks it up and eats it, he is *perceiving* the apple in its relation to a total situation; the apple is seen in a particular location with reference to other objects. These spatial relationships need not be explicitly noted, but if the person is *recognizing* he sees the apple and in addition to the act of picking it up he names it and notes that he has seen it before; he finds it a familiar object. (3) Imagery is another simple process in intelligent behavior which comes to light upon introspection. There are also several processes of a more complex nature such as (4) comparative judging, (5) conception and (6) reasoning. All of these will be examined in their turn.

The Nature and Products of Introspection. It was learned in the introductory chapter that introspection is a structural method of analysis. Now that the method is definitely confronted for the first time, it should be recalled that any structural analysis discloses events or objects whose existence was not previously evident. Introspection is not an exception to this rule. To illustrate, an observer knows perfectly well when he recognizes an object, but the various mental activities which come to light upon an introspection of recognition are not apparent. They possess no identity until he abstracts them from the total, unified experience. By introspection the observer induces mental processes which, without introspection, do not exist for him. Accordingly, the abstracted products are not to be confused with the event before it was analyzed; they are events of a 'simpler' order. Previous to analysis the event is a *mode of behavior* on the part of the individual; out of that event introspection abstracts processes which are classified as *mental.*

Woods' Experiments on the Process of Recognizing. In 1916, Woods [9] published the results of an elaborate introspective study of recognition. She used phonograph selections, odors, objects of touch and forms of printed letters, all of which were at first unfamiliar to her observers. As they

[9] Woods, Elizabeth L., "An Experimental Analysis of the Process of Recognizing." *Amer. J. Psy.,* 1915, Vol. 26, 313–387.

inspected these objects for the first time they heard the experimenter announce the names. Upon subsequent exposures the observers attempted to identify the objects by name. This procedure was repeated until recognition followed immediately upon the presentation of the stimulus. The appended introspection illustrates her data.

Stimulus: Coast Violet. Second presentation: first recognition. Time for recognition, 9 seconds. "It is familiar but I can not get its name. Attention lingered upon the actual quality of the odor only for an instant. The sensation seemed to be of slight intensity and was visualized, at the opening of the nostril, as an amorphous gas. Then there appeared a series of visual and vocal-motor (inner speech) images. First, the visual, in which I saw a portion of ground and on it was a plant just coming up, something like a skunk cabbage; its top was chopped off.[10] Vocal-motor strain to say something and there was nothing to say. Strain was so intense that attention shifted for an instant to a visualization of my speech apparatus, with muscles in state of contraction. Only thing that came in was the word, herb, repeated two or three times. State of tension, localized in the speech apparatus and about the face. These processes, together with the accompanying pleasant affective toning and the absolute predominance of this imagery—the abandoning of everything else —was my analysis of the recognition. . . ." [10]

Woods' results show that a feeling of familiarity is an outstanding feature of recognizing. This response is essentially motor in character as evidenced by the observer's numerous reports of muscular sensations. Although this reaction differed from individual to individual it generally involved a loosening of the muscles about the eyes and mouth and a sudden development of tensions in the throat as if the observer were about to say something, presumably to give the stimulus a name, or to remark, Uhm, I know that one. Another outstanding feature consisted of those visual, verbal or other forms of imagery that referred to previous events in which the stimulus had figured. As recognition reached its final stage of development after several presentations of the object, it included a prompt identification of the stimulus in terms of

[10] The 'skunk cabbage' was an association that appeared the first time the stimulus was presented. *Loc. cit.*, 336.

imagery and a widespread but brief motor reaction involving the face, throat and chest muscles. The subject 'warmed up to the stimulus' suddenly and then relaxed. The 'warming up' was a mechanized familiarity reaction. These, presumably, are the activities to which recognition of a person on the street might be reduced should the observer stop to introspect. Woods' contribution consisted not only in showing into what phenomena recognition could be broken down, but in demonstrating the falseness of previously existing theories that, during recognition, thought-elements are employed which could not be analyzed. Her results also indicate that the organism is responding essentially as a whole; muscles are quite as important as the brain!

The Image. In discussing Woods' experiment we have been introduced to an abstracted phenomenon the existence of which few persons outside the psychological laboratory discover; it is the *image*. When a person recalls an experience he had camping the previous summer he sees in his mind's eye the lake front along which he pitched his tent, the evergreens behind and the mountain rising toward the sky on the other side of the lake. This is *visual* imagery. There are many other kinds. It is easy to imagine a tune running through one's head. Reduced to its simplest terms by introspection this experience consists of auditory imagery of the music, together with vocal-motor imagery of singing the melody. One can similarly imagine the sound of a locomotive whistle or a certain person's voice, or the tone of a violin. So too, one can construct in imagination all kinds of visual experiences, odors, tastes, touch experiences (cold, warm, pressure, pain) and bodily movements (kinaesthetic images). All these processes resemble the material that can be abstracted from imaginative activities such as day and night dreams, reveries and memories.

Imagination. The imaginative person indulges in lengthy trains of ideas which are largely reducible to imagery. He dreams, constructs air-castles and is quick to catch a subtle point in conversation. He anticipates what one is about to say and with a word or two as a cue, reads much more into a situation than is actually there. He sees figures and faces in

the flames of a campfire, objects in ink-blots and reads between the lines of the printed page.

Every child passes through an imaginative period during which he delights in listening to fairy stories and tales of adventure. He lives in a world of make-believe; he plays Indian with his bow and arrow; kills the giant Goliath with a stone from his sling; makes imitation medicines from colored waters and goes about the house treating imaginary patients; from a soap box he delivers an oration to an imaginary crowd. He is inquisitive and asks questions of every conceivable sort; he is growing in ideas and much of his time is spent in making discoveries. Images play an important part in all these activities. The child between the ages of four and seven is likely to confuse his imagination with his memory; he weaves facts out of whole cloth and accepts them as the truth. His father returns from a hunting expedition with tales of bear shooting; a few days afterward the child runs into the house, screaming and out of breath, quite sure that he saw a bear peering at him through the rose hedge in the back yard.

Children, particularly girls, frequently play with imaginary comrades, talk to them, scold them and sympathize with them. These playmates sometimes persist for months at a time. Now and then one finds a child who has difficulty in outliving these phantasies, because of unhappiness in the home. She may even create imaginary parents of the desired qualities, meanwhile denying relationship to her real parents; then the condition is known as a *foster-child phantasy.* In all of these experiences images are 'real'; the imagined is the real world.

In adult life imagery functions in memory experiences and especially in art and scientific invention. The painter, sculptor, musician, designer, architect and writer live by their imagination. Frequently their creative trend develops early in youth. Indeed, without the existence of imagination we would not have had a Dante, a Shakespeare, a Euclid, a Newton or a Pasteur. We would not have our airplanes, wireless, steam engines, anaesthetics and X-ray machines. And as for group life, without imagination we would never have had our legends and folklore, our stories of fairies, of Santa Claus and Hercules, and no conception either of the devil or of God!

Relation of Imagery to 'Sense Experience.' In the older terminology imagery depends upon 'sense experience.' For example the congenitally blind do not see in their dreams and have no conception of brightness, color and visual form because they have never had visual experiences. They see in their imagination what we 'see' from the back of our heads, nothing. Where we use imagination we generally begin of course with something familiar; inventions are the products of imagining familiar objects and of employing familiar principles in *new relationships*. In his novel, 'The First Men in the Moon,' H. G. Wells pictures the inhabitants of the moon as peculiar insect-like creatures standing erect with features half insect and half human. Again, the airplane is a familiar motor and a familiar kite seen in imagination in novel relationships or verbally described to oneself in novel ways. In spite of these facts, experience does not explain imagination (cf. page 316).

Methods of Studying Imagery. A crude and rather unreliable but interesting method of studying imagery by a questionnaire was first attempted by Francis Galton.[11] He found that individuals who are accustomed to thinking in abstract terms possess little concrete imagery such as visual, olfactory (smell) and the like, but a wealth of verbal imagery of words. This is to be expected since much of abstract thinking is accomplished in silent speech. Since that time the questionnaire has been a popular method of studying imagery. The following is a short but typical example of such a questionnaire:

1. Think of a window display in a drygoods store. (a) Are the colors vivid and real, of the red velvet evening dress, the yellow dancing frock, the green and white sport suit? (b) Are the objects well defined and clear cut? Can you see them distinctly in their form and outline? (c) Can you see the whole display at once, or only part of it, while the remainder is blurred?

2. (a) Can you call up the tone of a violin, a clarinet, a saxophone, a flute? (b) Can you call up the high pitched noise of a cricket, a locust, the low rumbling of a waterfall, the low pounding of waves upon the shore?

3. (a) Can you feel in your imagination the softness of

[11] Galton, Francis, *Inquiries into Human Faculty and Its Development*, 1883.

velvet, the roughness of sandpaper, the sharp prick of a pin, the heat of a fireplace against your face?

4. (a) Can you think how 'puddle' is pronounced? Hold your tongue between your teeth and try to say, 'Mississippi,' 'Tennessee,' 'Massachusetts.' Is it difficult? Is the word-image distinct?

5. Think of getting up from your chair and opening the window. Can you feel in imagination all of the movements you would make?

With the use of a questionnaire of this kind it is possible to make a rough inventory of an individual's imagery, and even to achieve a rough quantitative measurement by estimating the imagery in terms of 1, very vivid, 2, vivid, 3, fairly vivid, 4, faint and 5, very dim. This procedure discloses the fact that visual imagery is ordinarily the easiest to abstract from everyday experiences and that imagery of movement, especially of the speech muscles, is the most difficult. Consequently, a method of this sort is subject to the error that the observer may be able to abstract, with more practice, imagery which he previously 'overlooked.'

The Problem of Eidetic Imagery. For several years a group of investigators (Jaensch, Kroh, Busse) in Germany have been studying a special type of imagery to which they give the name 'eidetic.' (Greek, *eidos,* meaning form.) After an observer studies an object, say a picture on a certain background, it is possible immediately after the exposure of the picture to see it with almost photographic clearness especially if a background like the original is fixated. So definite is the imagery that its time of appearance and duration can be ascertained. Children are more likely to experience this imagery than adults and certain children are more eidetic than others. Occasionally, in case of colored objects, the eidetic image is followed by the *complementary* of the original color. This fact would lead one to suspect that the complementary color was akin to a negative after-image, a very common phenomenon in vision (see page 388). However, these investigators differentiate between eidetic imagery and negative after-imagery; they also insist that eidetic processes are not to be confused with the ordinary memory imagery employed in recalling events of the past. On the basis of their results

they have constructed a new system of psychology, a study of which is beyond the scope of this text.[12]

Comparative Judging. So far, by the method of self-observation we have abstracted from intelligent behavior perception (not yet discussed in detail), recognition and imagery. The next process in complexity is the explicit perception of one object in its relation to another in the total situation. In ordinary perception these relationships are not observed as such, but in the activity under discussion *at least one concrete relationship between two objects is explicitly recognized.* This procedure is known as *comparative judging.* Perceiving one line longer than another, one tree taller than another, and one apple larger than another, are simple examples. Absolute judging, such as 'The coffee is hot,' 'The stone is heavy,' 'The tone was loud,' are outgrowths from previous comparative judgings. The latter are the more basic processes.

Fernberger has made an intensive study of judging.[13] His materials consisted of pairs of weights, lines, gray papers and sounds. In each procedure he first presented a standard stimulus and followed it after a short interval by a stimulus which his observers judged to be equal in some respect, or greater or less with reference to the standard. After the observer completed his judgment he described his experiences in detail. The following summarizes a typical introspection:

No. 34. Stimulus: weights. Judgment: lighter. "After lifting the first weight I had a good . . . kinaesthetic image localized in the back of the forearm, hand, and especially the wrist; this persisted up to the second weight. Seemed to be a tendinous sort. The second weight was lifted . . . it came up easy. There seems to be a direct awareness of difference from a particular muscular set that hangs over. I seem to be set for a certain amount of effort. . . . Between the replacing of the first weight and lifting the second the image connected with the lifting of the first weight remains dominant . . . the differentiation seems to be entirely in the way in which the second weight comes up."[14]

[12] Allport, G. W., "Eidetic Imagery." *Brit. J. Psy.* (Gen. Sect.), 1924, Vol. 15, 99–120.

[13] Fernberger, S. W., "An Introspective Analysis of the Process of Comparing." *Psy. Mon.*, 1919, Vol. 26, 161.

[14] *Loc. cit.* Introspection number 34.

The observer perceives the second weight *in terms of the first.* This is made possible by an after-effect of perceiving the first weight in the form of a 'set' or 'readiness' to lift a similar weight. If the observer perceives no change in the 'set' as he lifts the second weight, he interprets it equal to the first; if his arm moves suddenly upward he interprets the second weight as lighter; if he experiences unexpected difficulty he reports 'heavier.' In judging lines the observer adopts a similar procedure; he looks first at the standard stimulus and then carries over a perceptual and motor 'set' in terms of which he perceives the second line. If he makes no readjustment in this 'set' he finds the two lines are equal; if he discovers himself fixating the background at one end of the comparison line, or if he fixates the end of the line and notices an eye-strain toward the space beyond, he perceives the line shorter. He judges the line longer when additional eye-movements are necessary to see the whole line clearly, or when he finds himself looking at a position toward the end of the line after expecting the end to be visible without further adjustment. The outstanding features of the 'set' that is carried over from the first to the second line are visual imagery and motor adjustments of the eyes. In the case of sounds and gray papers motor phenomena were less obvious. But the judging ran its course in much the same way with a perception of the second object in terms of a 'set' carried over from the first. Changes in this 'set' made necessary by actual differences in the object constituted the final stage of the judgment.

Discussion of Fernberger's Results on Judging. To the person who knows only that in judging he is comparing one object with another, an analysis like Fernberger's seems unreal, but the trained introspector can verify these results for himself. Fernberger ascertained those processes into which judging broke down under the conditions he prescribed. He did not explain judging by his analysis of it. Nevertheless such facts as he established are of systematic importance; they present a detailed picture of judging. Previous to his investigation it was uncertain whether or not judging involved types of mental processes not reducible to imagery and sensory

processes. In fact the supposition prevailed that it involved unique thought-elements, but Fernberger's results failed to substantiate this hypothesis.

The Concept. The direct memory of a color, a tone, a touch sensation or any sensory process is called an image. The memory of a perception is called a *concrete idea.* The 'set' which has just been described in connection with judgment was a *memory idea* of the first object carried over until the second object was perceived. This memory idea resulted in the apprehension of differences between objects but, as such, it involved an implicit perception of similarities. The memory of similarities between objects is called an *abstract idea* or *concept.* It is therefore an outgrowth, genetically, of comparative judging. Remembering similarities between objects enables the observer to group these objects into classes and leads to processes of reasoning. A scientific law is a concept derived from noting similarities in the behavior of the same object under different conditions. A statement with regard to any kind of uniformity or generality is the expression of a concept that makes possible the rational prediction of future events. Moreover, definitions of all sorts are systems of concepts.

Uses of Concepts. The entire field of mathematics is conceptual. A person uses concepts whenever he adds, divides, multiplies and subtracts, in fact whenever he employs any kind of symbol. He applies a concept like that of gravity feed when he searches for the trouble with his stalled Ford, another concept when he postpones his deer-hunt until the dry season is over, and another when he displays a sign over his office door, Money to loan. The use of concepts and the making of generalizations are the outstanding features of intelligent behavior from the standpoint of self-observation.

Fisher's Study of the Concept. The growth of the concept in adults was investigated by Fisher in 1916.[15] In order that she might discover the descriptive features of the concept in its early stages of development, she provided her subjects with material which meant practically nothing to them

[15] Fisher, S. C., "The Process of Generalizing Abstraction, and its Product, The General Concept." *Psy. Mon.*, 1916, Vol. 21, 5–213.

at the outset. She invented several sets of nonsense figures, each member of a set corresponding to an individual object; the set as a whole corresponded to a species. She gave each series a nonsense name (see Figure 9). She then familiarized her subjects with this material until they had acquired a concept of each group. Meanwhile by the introspective method she obtained from her observers detailed descriptions of the procedures they adopted in studying the figures and in describing them from memory.

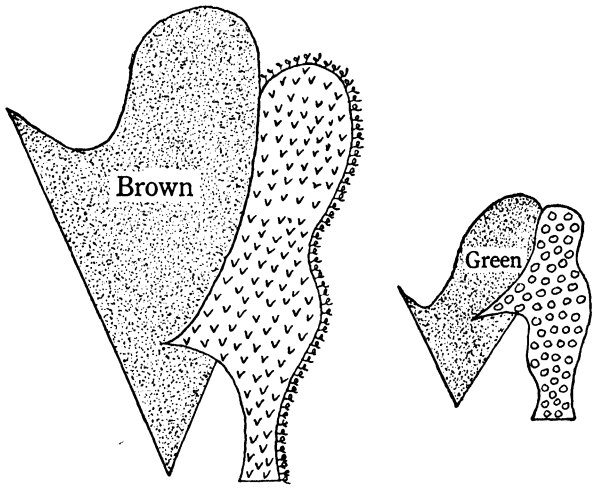


FIG. 9. TYPICAL 'DERALS' (Fisher).

The first stage in the development of the concept was the remembrance of individual figures largely in terms of concrete visual, motor and other images. Later on these concrete images became hazy and attenuated; details having to do with the *variable features* of the objects disappeared while details pertaining to *repeated features* remained. Similarities between the different objects, then, were being abstracted from the objects as wholes and separated from the features which made one object different from another. As time went on these abstracted features were remembered less by means of visual and more by means of kinaesthetic and verbal imagery,

until finally the name of the figures sufficed as the material of the concept.

Reasoning. Reasoning consists of solving a problem; it is an adjustment made to a novel situation by employing a concept. For example, Figure 10 represents a room, 20 feet long and 10 feet high. There is a spider on one end wall, 5 feet from either side and 1 foot from the ceiling. There is a fly on the other end wall, 5 feet from either side and 1 foot from the floor. How far (in feet) must the spider crawl to reach the fly, keeping on solid surface the entire distance?

In natural life situations reasoning always commences with an unfulfilled wish, with a doubt or with a thwarted purpose. In the relatively artificial situation of reading these pages

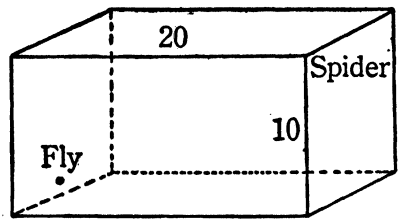


FIG. 10. THE FLY AND SPIDER PROBLEM.

the unfulfilled wish may be merely that of desiring to solve the problem just mentioned. You first note the dimensions of the room and trace with your eye a straight perpendicular line from the spider to the floor, another straight line across the middle of the floor to a point beneath the fly and a third, short line from there to the fly. Then in terms of inner speech you add 9, 20 and 1, and get 30, which you think is the correct answer. While you have been applying the concept 'a straight line is the shortest distance between two points' and have therefore been reasoning, you have applied the principle incorrectly. Thirty feet is not the shortest distance!

Your purpose is now definitely thwarted. What! Thirty feet is not the correct answer? You doubt the statement, and forthwith attempt more vigorously than ever to reason. Obviously you must search for an additional concept; you reflect that a straight line is ordinarily a phenomenon of a

single plane. You have been dealing with planes in three dimensions. Is there a way in which you can reduce the walls of the room to a single plane? Yes, by imagining the walls of the room opened out like an unfolded cardboard box. You proceed to draw the appropriate diagram with the spider and fly in their proper places and note at once that a straight line from the one to the other passes diagonally from the spider to the ceiling, across one corner of the ceiling, diagonally across and down toward the opposite end wall and diagonally across one corner of the wall to the fly. You have applied a second concept dealing with the hypotenuse of a right triangle. With the use of that concept you arrive at an answer smaller than 30.

Summary of Principles Pertaining to Intelligent Behavior

Products of Introspective Analysis Summarized. Let us summarize the facts of intelligent behavior as they reveal themselves to self-observation, carrying the discussion, however, beyond the stage at which experimental studies have left it. *First,* intelligent behavior exhibits various degrees of complexity ranging from perception to reasoning, each level representing a certain stage in a growth or maturation process in the life history of the individual. These stages are perceiving, recognizing, comparative judging and reasoning. *Associated with stages one and two is imagery, with stage three, ideas, and with stage four, concepts. Second,* no matter how complex they happen to be originally, the psychologist can break down all of these activities into relatively simple phenomena known as sensory processes and images. These latter are fine abstractions, comparable very roughly to the chemist's molecules and electrons. Midway, in this breaking down process, the psychologist finds many other phenomena, roughly like the chemist's compounds, for example the *Aufgabe, the conscious attitude* and *'mental set.'* The *Aufgabe* is an apprehension of the goal with reference to which behavior is occurring at the time; it has also been defined as a 'task-consciousness'; but in ordinary language it is a 'purpose in

mind.' Much of thinking is accomplished in terms of these conscious attitudes, which are essentially motor in character. Doubt, acceptance and rejection, certainty, uncertainty, belief, expectancy and anticipation are examples. They are the *modi-operandi* or activities *in terms of which* recognizing, judging and reasoning are initiated, directed during their course, inhibited, changed and concluded. In other words, they are the dynamic processes in terms of which thinking is *carried on.* We shall have occasion to discuss the *Aufgabe* and *mental set* again later on (page 334) and we have already seen how a willingness to accept ideas, or a will to believe, functions in connection with suggestion. Many of these activities belong quite as much to the category of emotive responses—wish, desire and the like—as to the category of intelligent behavior.

In order to illustrate in more detail how conscious attitudes function as the media of thinking, consider the example of comparing two weights. At the outset the observer establishes the goal. In the usual language of the introspectionist this process involves a 'consciousness of the task' and an attitude of *accepting* the task. This is a motor attitude of preparedness, the introspective description of which shows that the observer is under stress while the objects to be compared are anticipated in terms of visual or verbal imagery. This motor attitude constitutes the major part or content of the thought process. It is a content without which, as Wheeler has shown (page 333) in his study of choosing, the thought process does not go on. This attitude persists while the weights are being lifted; indeed, the movements of manipulating the weights are elaborations and definitizations of the original attitude of preparedness and are processes by which the tension is resolved. The second weight is lifted and an attitude of certainty arises. This attitude, under the general direction of the goal to complete the judgment, conditions a change in the observer's procedure and leads to a more detailed inspection of the weights. Then, as the result of noticing a cue that had hitherto gone unobserved, an attitude of belief or certainty arises that one of the weights is heavier, an attitude which carries the process of comparing to its con-

clusion, that is, it constitutes the final step in the judgment. The entire procedure is a unified and continuous response, not to be explained as a seriation of separate attitudes linked together, and not to be regarded as a whole summated from discrete parts. Rather, it is an organized reaction from its beginning to its end, proceeding from an initial tension (the acceptance of the task) toward a remote end previously established.

The Goal in Intelligent Behavior. We find that no matter with what level of complexity we are dealing, intelligent behavior follows the same laws; it is essentially the same activity everywhere. It always takes place with reference to a remote end or goal, which may or may not be realized as a goal by the reacting organism. The bird flies back to its nest without explicitly interpreting the nest as a goal; the business man returns to his home at night without stopping to think that home is the goal. But when a person deliberately constructs specific features of the goal for himself, or identifies the goal, as such, his behavior is considered purposeful. In any case, in conscious behavior the goal is perceived in some way; it is seen, heard or felt, and in the higher animals and in man it may be imagined (cf. page 242).

Considered apart from the perception of it, the goal consists of conditioning factors of two sorts, one external to and one within the organism. In the behavior of the simpler animals, the external aspect may be a light, a dark place, a warm place or a cold one, food, or an object emitting an odor, the reaching of any one of which brings release from stress. The internal aspect is a state of equilibrium, a balance of tensions. In the higher animals the external aspect of the goal may be, aside from those just mentioned, a sex object, situations having to do with nest building and the care of the young. In human beings these situations become extremely complicated, especially in civilized society. In both animals and human beings the internal aspect is still a balance of tensions, and in the latter the individual's concepts of himself and of his relations to the group play a dominant rôle in determining his *Aufgaben.*

Another interesting problem arises in connection with

imagining the goal when it is not objectively present to the organism. This imagining of the goal is accomplished in terms of visual, verbal or other forms of imagery. The imagery symbolizes the missing goal, or in other words functions as a substitute until the goal is available as an actually perceived situation. For example, a hungry person visualizes the cupboard, or he remarks to himself, There are cookies in the cupboard, and forthwith proceeds to the goal. Moreover, not all goals are specific places or objects to be reached; they are frequently *situations* which relieve tension. The presence of a person whom we dislike is a situation which arouses tension, and in resolving the tension we seek the nearest convenient place where he will not be encountered. Situations, as goals in human behavior, may be extremely complex, for instance the goal of giving one's children a good education.

In any event, in considering the external goal as a point of low tension we must think of the human being and the goal as belonging to one energy system. The human being is a body moving under tension toward the goal and the goal is the situation that ultimately relieves the tension. But, part of this tension within the organism is caused by external stimulation, which includes the goal, and part of it is caused by the muscular contractions of the organism itself. As soon as contraction begins there is an increased stimulation of the nervous system and an increase in the disturbance of internal equilibrium. It is this muscular tension that gives to a goal its internal aspect. In other words, in case of the behaving organism there are two conditions to be met in resolving the tension. The external goal must be reached and there must be a return of balance of neuromuscular tensions within the organism. The balance is characterized by relative quiescence or relaxation.

Value of Structural Analysis of Thinking. It was at one time assumed that a given case of intelligent behavior, such as comparative judging, could be *explained* by reducing it to sensations and images. There later sprang up a school which attempted to account for these phenomena in terms of conditioned reflexes. (Discussed in Chapter VIII.) Never-

theless, while both attempts were unsuccessful it is important to analyze various modes of intelligent behavior in order to understand their relationships to each other and to human behavior as a whole. For example, analysis reveals different forms of intelligent behavior that vary in their complexity; as we proceed from an analysis of the simple to the complex we obtain a rough picture of their evolution.

Furthermore, introspection reveals the different aspects of thinking which must be subjected to functional analysis if facts are to be ascertained leading to the prediction and control of the processes in question. That is to say, structural analysis furnishes clues for the procedure of functional analysis (see page 15).

The Configurational Theory of Thinking Contrasted with the Association Theory. At one time, psychology attempted to account for thinking by resorting to laws of association. (Presented in detail on page 262). These laws were supposed to explain how discrete ideas first appeared as separate elements and later became connected into logical trains of thought. This standpoint necessarily implied that complex activities were derived from the simple. It made of the individual's first experiences a confusion of unarticulated elements; it assumed that thinking was *no more than* an aggregation and rejuggling of earlier and simpler experiences.

A number of problems arise when the configurational and association theories are contrasted. *First,* any whole possesses a unity which is lost when reduced to its parts. Suppose an attempt is made to proceed in the opposite direction, that is, to construct a whole from its parts. These parts can no more be assembled into a unified whole without gaining something than a whole can be disintegrated without losing something. This something gained is after all exactly what we are attempting to explain, but since it is something *new,* more than existed in the beginning, what existed then will not account for it. The elements with which we commenced may be necessary conditions for obtaining the whole, but they are not *sufficient.* The configurational view supposes that thinking does not evolve from isolated elements to combinations

of elements but that, whatever its degree of simplicity or complexity, it possesses its own organization from the outset.

Second, the structural analyses of thinking made by Woods, Fernberger, Fisher and others, do not yield information leading to prediction and control. They are *descriptions* of thinking, not systematic studies of the conditions under which it takes place. Only when the latter are ascertained by functional analysis can thinking be predicted and controlled.

Third, basing thinking upon elements that are combined by means of association does not explain what makes a train of thought go on and what finally *terminates it.* In the configurational view a given thought process is an organized response from its beginning to its end. Given a complex stimulus-pattern and a certain maturity of the nervous system, a train of thought commences as a reaction already possessing an organization of its own, exhibiting itself first as the perception of a problem. It is this organization existing to begin with that determines the subsequent details of the train of thought.

Fourth, the perception of the problem is a directional activity proceeding, by virtue of its own organization, toward a goal, and the thought process is not complete until the goal is reached. The goal is established before the thought process begins. To state it differently, the perception of the problem is an incomplete response calling for continuous action until terminated by reaching the goal. The configurationists give the name 'structure' to the organized thought process, commencing with the perception of the problem and ending with the solution. To the termination of the thought process they give the name 'closure phenomenon.' The perception of the problem is a response which demands its own completion, and as we have seen, it involves a dominant motor factor in the form of an attitude; this attitude is a tension which seeks its own resolution. The initiation and termination of a given thought process then becomes intelligible for the same reasons that make 'physical action' intelligible. This view of thinking brings it into relation with the law of least action. During the resolution of the tension thinking proceeds over the most

direct route in time, under the circumstances, from the perception of the problem to the 'closure.' (Koffka, Köhler.)

Fifth, while the configurational and associationistic theories of thinking are based upon incompatible assumptions, there is no essential conflict between the *facts* of thinking as described by the introspectionist and the facts as described by the configurationist. The discrepancy comes in explaining the facts. The two accounts are supplementary when the data of the introspectionist are treated in the light of configurational principles. Indeed, without the facts from introspection, the configurationist would have no information about the thought process, nothing to explain in terms of its chosen principles.

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CHAPTER VI

EMOTIVE BEHAVIOR

Introduction

In Chapters II and III the subject matter consisted of human behavior taking place in a relatively unlimited social environment. Since behavior is not defined in terms of itself but in terms of the conditions under which it takes place, so long as the social conditions of behavior were being considered behavior was defined as social. In Chapters IV and V the human being was studied under *more limited conditions.* Various kinds of abstracted or isolated situations were selected and the resulting behavior described and explained. These situations exhibited the outstanding features of being novel and of having a problem character, and the organism responded to these features in their relations in accordance with its degree of phylogenetic or ontogenetic (individual) development. The convenient adjective, intelligent, was chosen to describe the behavior conditioned in this fashion.

In the present chapter a study is commenced of another mode of behavior which may be called *emotive.* Like intelligent behavior, it is always a response to a total situation, but in this case the outstanding condition is found *within the organism itself.* The investigation of emotive behavior will introduce a more refined scientific technique than has been described heretofore. This technique is employed for the purpose of ascertaining as definitely as possible the precise conditions which determine the dominant features of emotive behavior, and also for the purpose of *measuring* the emotive response.

Examples of Emotive Behavior. Human beings display a great variety of emotive reactions, ranging from the

relatively simple to the extremely complex. *First,* and simplest among them is being pleased and displeased, which take the varied forms of being satisfied and annoyed, of liking and of disliking. In a *second* and more complex group belong fear, anger and love. In addition to fear proper, the fear-reaction occurs in numerous forms such as shyness, timidity, anxiety and dread, depending upon the circumstances under which it takes place. Anger appears in its more intense states as rage and also in a modified and more complex form as hatred, jealousy, envy, vindictiveness and hostility. Love reactions are generally classified into two major groups, one pertaining to the mutual relations of the opposite sexes and the other to parental and filial relations. Certain writers include wonder and disgust along with fear, anger and love in a group of 'primary human emotions'; they also include positive self-feelings (assertion, pride) and negative self-feelings (humility, abasement). In this group might also belong the various expressions of joy. The *third* group pertains to emotive reactions which are still more complex and which, for the most part, depend upon a higher stage of mental development than is necessary for the first two groups. Hatred, jealousy, grief, awe, pity, gratitude, hope, remorse, pride, scorn, shame, revenge and exultation are only a few of a long list. Then, in a *fourth* and last group may be placed the religious, moral and aesthetic sentiments. These are the most complex varieties of all and they depend upon a still greater maturity of the individual, acquired through the influence of a strictly social environment.

Many attempts have been made to analyze these and many other emotive reactions but the processes are so variable and complex that little more than common sense information is available concerning them. Of necessity, therefore, a scientific discussion of emotive behavior will be limited to the simpler varieties. This discussion will lead us, first, to a consideration of a famous historic problem, the problem of emotion and instinct, which has become intimately associated with the question of inherited behavior. In studying these problems from the configurational standpoint we shall be introduced to some striking conceptions.

History of the Problem of Emotion: the Separation of Emotion from Instinct

The ancients recognized the tremendous rôle played by emotion in daily life, and their original efforts to explain it introduced problems which have been handed down to the present time. They located the baser emotions in various organs of the abdomen and the nobler emotions in the heart. Expressions like 'sorrow breaks one's heart,' and 'be kind hearted' date from this period. Even the expression 'green with envy' could no doubt be traced to an ancient localization of jealousy in the liver. We shall see that this early associating of emotion with the internal organs contained an element of truth and crudely anticipated a famous modern theory advanced by James and Lange.

Conflict Recognized as a Condition of Emotive Behavior. Aristotle associated pleasure with assent and furtherance of action, and pain with hindrance and negation. Zeno, the Stoic, anticipated another aspect of the furtherance-hindrance theory in his view that emotion was a movement in the body in opposition to the nature of the soul. *This was an early recognition that hindrance, as a condition of emotive behavior, implied a conflict of goals, a conception which holds an important position in modern psychology.* Interesting advances were made in this type of theory in the 17th century when Thomas Hobbes (1588-1679), a British philosopher, elaborated the notion of conflict as a condition of pleasure and pain. A certain kind of motion, he thought, proceeded from the head to the heart, and when this motion *facilitated* the vital processes already taking place the individual experienced delight or pleasure. When there was a *conflict* between the two kinds of motion the individual experienced pain (displeasure). Hobbes also emphasized the notion that pleasure and pain led to certain other and more complicated responses which he called: (1) appetite, or a striving toward an object or a situation, (2) aversion, a striving away from something unpleasant, and (3) desire.

Certain of these appetites, for example the appetite for food, were *born within us.* Thus in his theory of emotion

there emerged another concept, that of *inherited behavior, or instinct.* This concept was to have far reaching consequences, for as a result of the mind-body distinction *instinct was gradually defined in such a way that it became a separate problem from that of emotion.*

Antecedents of the Emotion-Instinct Distinction: Descartes and Spinoza. Descartes recognized the dependence of emotion upon the bodily organs. According to him the passage of 'animal spirits' (an anticipation of the modern conception of nerve impulses) through the body gave rise to joy, anger, and fear, which in turn prepared the body for the execution of such wilful acts as were dictated to it by the soul. The soul, Descartes thought, resided in a small structure in the center of the head now known as the pineal gland. Once emotions were initiated in the body the soul could alter them only indirectly. On the other hand, emotion acted on the soul in various ways. For example, fear incited the *will* to flee and courage incited it to fight. Conflicts frequently arose in the pineal gland when there was a clash between the animal spirits of the body and the action of the will. Thus Descartes crudely explained those indecisions that involve emotional impulses on the one hand and better judgment on the other. *In his dualistic separation of motives (mind) and physical action (body) is found a view which curiously resembles a modern hypothesis advanced by McDougall.* Fear led to flight and anger to fighting, said Descartes; McDougall has proposed a parallelism which makes fear an emotion and flight an instinct, mental and physical views, respectively, of the same thing.

Spinoza (1632-1677) defined emotion in a rather modern fashion. "By emotion," he said, "I understand the affections of the body by which the power of acting of the body itself is increased, diminished, helped or hindered, together with the idea of these affections." [1] We shall soon discuss a theory which is hardly more than an elaboration of this view. Further, according to Spinoza, man possesses a natural tendency or 'appetite' to preserve his body and mental life. Desire,

[1] *Ethic,* tr. 1883, pt. III, Def. 3. Quoted by Titchener, *Textbook,* 479.

joy and sorrow are various *expressions* of this 'appetite' for self-preservation. Notice again the *implicit* separation of emotion from instinct. Emotion is defined in subjective terms; it is conceived as a *mental state* opposed to which are the *physical activities* of the body. The latter are construed either as causes or as effects of emotion. Hence the inclination today to speak of bodily movements as effects or expressions of emotion. The mind-body problem was responsible for this separation.

The Final Separation of Emotion from Instinct. Interest in problems of inherited behavior was greatly accentuated by the publication, first of Lamarck's (1744–1828) "Philosophie zoologique" in 1809 and later of Darwin's "Origin of Species by Means of Natural Selection" in 1859. These two opposed theories of evolution engendered additional questions in connection with emotion. They brought to the front the whole matter of acquired *versus* inherited forms of behavior, including the problem of the origin of emotional and instinctive responses in the evolutionary history of man. It was in 1872 that Darwin published his book dealing with the latter problem, "The Expression of Emotions in Man and Animals."

A materialistic philosophy which had been smoldering for some time now reached the height of its development and appealed to these theories of evolution in a protest against the miracle of creation and against the supposition of a vital principle which would account for life. This movement had the effect of prolonging the sharp distinction between mind and matter, for there were many who would not accept a materialistic conception of human life. Human life, they insisted, represented something more than a mechanical aggregation of material atoms, and so they clung to the subjective definition of mind as a harbor of refuge from the inroads of materialism. *Emotion, then, came definitely to be regarded as something mental, and instinct, composed of the expressive movements of emotion, was something physical. The mind-body distinction had finished its work.*

Darwin's Theory of Emotional Expression. *Once emotion and instinct were separated, the problem arose of explaining their relationship.* Darwin, for example, wrote as if

expressive movements made during emotion were to be regarded as *accompaniments.* In general there were for him three kinds of movements: *First,* there were *serviceably associated habits.* In anger a person shows his teeth, clenches his fist and assumes as fierce an attitude and countenance as possible. Darwin supposed these reactions to be reminiscent of the days when man's ancestors fought with tooth and nail. They have been inherited from a time when they were useful in a struggle for existence against enemies. *Second,* there were *antithetical movements.* Certain states of mind led habitually to serviceable actions like those of group 1. Suppose, however, that a certain stimulus induced a directly opposite state of mind. Then there followed a tendency to make an opposite set of movements, although the latter were of no value in themselves. In this category Darwin placed actions like the fawning of dogs and the purring of cats. There was a *third* group of movements which, Darwin thought, depended upon *direct nervous discharge.* The stimulus affected more of the nervous system than was necessary for the production of useful movements, thus giving rise to extraneous and sometimes disadvantageous reactions. Darwin placed in this group such phenomena as trembling, profuse perspiration and discharges from the alimentary tract during fear.

The James-Lange Theory of Emotion. Attempts to bring emotion and instinct together again were soon to reach a climax. Independently of each other, William James, 1884, and C. Lange, in 1885, proposed views which have become known as the James-Lange theory of emotion. The theory is often presented as a distinctly novel conception but it contained very little that was actually new. However, it was much more precise than previous views. Briefly, the theory assumed that immediately upon being confronted with an exciting situation the organism reflexly or instinctively made a host of bodily reactions like those described on page 198. *There was no emotion until the individuals became aware of these reactions. The 'consciousness' of these reactions was the emotion.* The physical reaction caused the mental; hence instinct and emotion were at last together again! The authors stated their theory so positively and accumulated so

much evidence to prove it that a vigorous discussion immediately developed.

Criticisms of the James-Lange Theory. *First,* among the objections to this theory, it was claimed that the organic reactions were nearly the same for opposed emotions, hence the reaction could not be the cause of the emotion. Thus, Titchener objected that there are tears of joy and also of rage as well as tears of sorrow. A person strikes in fear as well as in anger, or for the sake of being cruel; he runs as hard to overtake a friend as he runs from a pursuing enemy; he trembles with eagerness or from a maudlin sentimentality as well as from fright.[2]

Second, it was contended that the James-Lange theory was logically unsound because it places 'the cart before the horse.' If the logic of the theory is followed strictly it must be concluded that a person is afraid because he runs; he does not run because he is afraid. That is, fear arises only after the physical impulse begins. Likewise, a person is sorry because he cries, joyful because he smiles, and angry because he has begun to fight. James would reply that if all the feelings of bodily symptoms are abstracted from emotion nothing remains out of which the emotion can be constituted. A closer scrutiny of the problem shows that the *whole difficulty lies in an effort to identify emotion with a single factor among its conditions. The organic reaction may very well be a necessary condition of emotion, yet not the only or sufficient one.*

Third, it was pointed out that the distinction between mind and body raised the unintelligible problem, How can a physical cause produce a mental effect? Later writers sought to avoid this dilemma by assuming that emotion and instinct were two aspects of the same process.

Discussion of These Criticisms. All of these criticisms seem more or less superfluous. They imply that the expressive movements and the emotion are successive events when after all they are one and the same process. In life situations the human being has no sensations of weeping separate from

[2] Titchener, E. B. *Textbook of Psychology,* 477.

the act of weeping. To segregate the sensations from the act is an abstraction which fails to explain emotion as an activity of the organism-as-a-whole. When emotive behavior is analyzed into motions and sensations the emotion no longer exists. What remains is *bodily movement* and *sensation.* Furthermore, to assert either that a man runs because he is frightened or that he is frightened because he runs assumes a distinction between subjective and objective phases of emotive behavior, or between cause and effect, that are non-existent in the original emotive situation. When frightened, a person is not doing two things; he is doing only one thing. This same criticism applies to the original theory. The first fact observed in any exciting situation is that of fright or anger or grief, and there is no natural splitting up at the time into sensations and movements. If by definition the reaction is divided into two parts, the mental and physical, the best expedient is to consider them aspects of the same process.

Cannon's Theory of Emotion. Cannon [3] raises several objections to the James-Lange conception of emotion and then offers a substitute theory. *First,* according to Cannon, total separation of the viscera (internal organs) from the central nervous system does not alter emotional behavior. Evidence for this statement comes from experiments by Sherrington [4] and also by Cannon, Lewis and Britton [5] in which dogs and cats displayed signs of emotion after surgical separation of the internal organs from the brain by cutting off the autonomic nervous system (page 214) from its connection with the brain. But of course nerve connections with *the external muscles were not altered. Second,* the same visceral changes occur in very different emotional states and in non-emotional states. The innervation of internal organs is diffuse, not

[3] Cannon, W. B., "The James-Lange Theory of Emotion: A Critical Examination and an Alternative Theory." *Amer. J. Psy.,* 1927, Vol. 39 (Washburn Commemorative Volume), 106–124.

[4] Sherrington, C. S., "Experiments on the Value of Vascular and Visceral Factors for the Genesis of Emotion." *Proc. Roy. Soc.,* 1900, Vol. 66, 397. Also "The Integrative Action of the Nervous System," Yale Uni., 1906, 260 ff.

[5] Cannon, W. B., Lewis, J. T., and Britton, S. V., *Boston Med. and Surg. J.,* 1927, Vol. 197, 514.

particular. Fever and asphyxia produce the same kinds of internal changes that take place during emotion. *Third,* the viscera are relatively insensitive structures and could not supply the nerve processes necessary for intense and elaborate emotions. *Fourth,* visceral changes are too slow to be a source of emotional feeling. *Fifth,* artificial induction of the visceral changes typical of strong emotions does not produce those emotions. The internal organic changes 'attending' emotion can be induced by injecting adrenalin into the blood stream. Under these conditions subjects report a wealth of organic sensations without real emotion. This we may interpret to mean that the organic conditions of emotion were functioning, but the resulting processes lacked emotional significance in the absence of exciting external stimuli or exciting behavior at the time the injections were given. *In other words, the goal of a true emotional reaction had not been set up, hence the organic reaction did not function in an emotional configuration.*

Cannon regards the display of emotional behavior under incomplete anaesthesia as evidence that the lower centers in the brain (thalamus, see page 449) subserve emotion. He also points to pathological cases in which these centers are cut off from the higher centers by lesions. Patients thus afflicted show excessive emotion. Moreover, an injury to one half of the thalamus occasions intensified emotional reactions on one side of the body, but the viscera can not function by halves owing to the fact that the center of control at the base of the brain is a single unit.

From all the evidence Cannon accepts the view that the source of emotion is the thalamus, and that the peculiar *organic* quality of emotion does not arise from the viscera or external muscles of the body. We can not accept this view. While it is unquestionably true that the thalamus intensifies emotive behavior, and while it is also true that the viscera can be cut off without eliminating the emotion, the evidence brought forward by Cannon proves only that organic and muscular stimulation are not the *sufficient* causes of emotive behavior. There are obviously other very important conditions, for instance perception of the goal and of the sig-

nificance of exciting situations, real or imagined. When these conditions are met we may presume the organic and muscular reaction to be an essential factor in contributing to the 'feeling-tone' of emotion. Cannon has not proved that the feeling-tone is supplied by the thalamus, so long as other possible essential conditions of the feeling-tone are not eliminated.

McDougall's Theory of Emotion. The assumption of a specific psychic process, emotion, associated with a specific physical response, instinct, was made by practically all investigators and writers in the nineties. Having made the assumption facts were organized to fit them. In the majority of these theories instinct and emotion were defined as inherited responses in contrast to intelligent and learning behavior which were regarded as acquired performances.

Thus, in 1908, William McDougall [6] defined instinct as the physical and emotion as the mental aspects of inherited behavior. Later he [7] published an extensive list of these activities with their physical and mental aspects.

Names of Instincts (Synonyms in Parentheses)	Names of Emotional Qualities Accompanying the Instinctive Activities
1. Instinct of escape (of self-preservation, of avoidance, danger instinct)	Fear (terror, fright, alarm, trepidation)
2. Instinct of combat (aggression, pugnacity)	Anger (rage, fury, annoyance, irritation, displeasure)
3. Repulsion (repugnance)	Disgust (nausea, loathing, repugnance)
4. Parental (protective)	Tender emotion (love, tenderness, tender feeling)
5. Appeal	Distress (feeling of helplessness)
6. Pairing (mating, reproduction, sexual)	Lust (sexual emotion or excitement)
7. Curiosity (inquiry, discovery, investigation)	Curiosity (feeling of mystery, of strangeness, of the unknown, wonder)

[6] McDougall, William, *An Introduction to Social Psychology.* New York: Scribner, 1908, 29.

[7] McDougall, William, *Outline of Psychology.* New York: Scribner, 1923. By permission.

8. Submission (self-abasement)	Feeling of subjection (of inferiority, of devotion, of humility, of attachment, of submission, negative self-feeling)
9. Assertion (self-display)	Elation (feeling of superiority, of masterfulness, of pride, of domination, positive self-feeling)
10. Social or gregarious instinct	Feeling of loneliness (of isolation, nostalgia)
11. Food-seeking (hunting)	Appetite or craving in narrower sense (gusto)
12. Acquisition (hoarding instinct)	Feeling of ownership, of possession (protective feeling)
13. Construction	Feeling of creativeness, of making (or productivity)
14. Laughter	Amusement (jollity, carelessness, relaxation)

McDougall's view has received practically as much notice as the famous James-Lange theory. It was the last classical attempt to unite emotion and instinct, and seemed to have answered the question, Which is cause and which is effect, the emotion or the instinct? by calling them *aspects of the same thing.* In reality, however, McDougall begged the problem instead of solving it because he provided no information about the 'thing' of which the two were totally different aspects.

The Problem of Instinct as Such

How Instinct Became an Entity! The separation of emotion from instinct led to an interest in the problem of instinct, as such, distinct from the problem of emotive behavior. This movement received a powerful impetus from observations on animals and children. Shortly it became necessary to enumerate and classify instincts in a way that implied the existence of specific inherited types of action. Listen to the definition given in 1890 by William James: "Instinct is usually defined as the faculty of acting in such a way as to produce certain ends, without foresight of the ends, and

without previous education in the performance." [8] And read the list of special human instincts which he accepted, largely, from previous writers: (1) Sucking, (2) biting, chewing, licking, grimacing, spitting out (in infants), (3) clasping, (4) carrying to the mouth, (5) crying, (6) turning the head (aside as a gesture of rejection), (7) holding head erect, (8) sitting up, (9) standing, (10) vocalization, (11) locomotion, (12) limitation, (13) emulation, (14) pugnacity, (15) sympathy, 16) hunting, (17) fear, (18) acquisitiveness, (19) constructiveness, (20) play, (21) curiosity, (22) sociability and shyness, (23) secretiveness, (24) cleanliness, (25) modesty, shame, (26) love, (27) jealousy, (28) parental love.[9]

Instinct an Explanatory Concept (?). Then instinct, like many another traditional notion, became an explanatory concept. Why did a child cry when hungry? It was because of an instinct to cry. Why did one fight when cornered in a dangerous situation? Because of an instinct to fight or to preserve one's life. Why did one take an interest in the opposite sex? Because of an instinct of race preservation, or a sexual instinct. Why did one prefer the company of others and band with others in co-operative enterprises? Because of a gregarious instinct.

Criticisms of the Instinct Hypothesis. In all these explanations it was assumed that the organism *inherited, completely,* the ways and means of executing all these activities. It was necessary, therefore, to add assumption to assumption and to suppose *preformed pathways* or *connections* in the nervous system which enabled the organism, when the occasion arose, to perform the full-fledged act the first time it tried. This involved the implication that without knowing how to carry out the act in question the organism knew how to do it! A curious paradox! Thus, *the mode of behavior for which an explanation was sought in instinct was not only assumed in the definition of instinct, but posited in toto in the form of inherited nerve patterns. The one explanation*

[8] *Op. cit.*, 383.
[9] *Op. cit.*, 403 ff.

as much as the other assumed what it intended to prove! It granted what it intended not to grant.

Second, no animal or human being is exactly in the same situation twice, and no two animals or two human beings are ever exactly in the same situation. Suppose for the sake of the argument that a human being inherits an instinct for self-preservation. Defining instinct in the conventional way it must inform him how to run, jump, climb a tree, hide, crouch, dodge, strike, pull, push, and do a thousand and one other things all of which result at different times and in different situations in preserving his life. The food getting instinct must instruct him in the process of picking bananas from a tree, of securing any food in any position seen at a distance, of handling knives and forks and of making other innumerable adjustments necessary in food getting. In short, since all his life he is directly or indirectly supplying his needs, preserving his life, propagating the race and caring for his offspring, *everything he does is instinct.*

When this dilemma was seen the term instinct was limited to mean only those activities which an organism executes completely the first time it tries. Accordingly, certain instincts, like eating, appeared at birth, while others, like the sex instinct, manifested themselves later in the life of the organism. Any act not completed the first time, but perfected later, was regarded as a learned performance, a habit based on instinct. Then the *third* difficulty arose, namely, that of ascertaining when the initial performance took place. At what time does the chick first move its neck and bill, when it pecks at the first food-object it sees upon coming out of the shell, or at an earlier period when it is wriggling inside the shell? It should be noted in this connection that chickens probably do not peck in the dark although they are starving. Is it likely under these conditions that a hunger instinct or pecking instinct was causing them to secure food? It might be assumed, of course, that the chick possesses a food getting instinct only when it sees food. But again difficulties arise for the chick will peck at small objects and large ones, edible and inedible ones, indiscriminately. Is the infant making specific

movements for the first time when he attempts to walk? Certainly not, since he has been kicking for months previously; he kicks in his mother's womb! Walking consists of those *kicking* movements that support the weight of the body.

Fourth, the concept of instinct implies that certain inherited acts are perfect when originally performed, but the facts prove the contrary. Eating is learned; efforts to carry out the reproductive act in all animals are generally awkward at first; the hen will brood upon corn cobs or stones, and so on. Instances without number could be presented showing conclusively that so-called instinctive acts are not 'adaptive,' as was formerly thought.

Fifth, attempts have been made to explain instinct by means of reflex action. Instinct, it was said, is a concatenation or combination of reflexes. In spite of its widespread popularity this view has recently encountered severe criticism because it is based upon the assumption that parts account for the whole. Moreover, as will be pointed out, behavior does not commence, in the organism's infancy, in the form of discrete and specialized reactions, which seriate and combine to make co-ordinated movements. Thus, neither fact nor logic supports the reflex theory of instinct.

The Problem of Inherited Behavior. *Sixth,* there remains another possibility. In order to avoid the specificity of the term instinct why not employ the concept of inherited behavior? But here we are no better off because to call behavior inherited throws no light upon the situation; it merely adds a difficulty. How does the act happen to be inherited? A close scrutiny of the problem leads to the conclusion that, whatever is inherited, it is not a particular set of *action* patterns in the nervous system that accounts for specific responses. There is instead a nervous system as a whole, including specialized sense organs like the eye and ear, supplemented by specialized organs of response like muscles and glands. *The problem of behavior involves the problem of inheritance only to the extent in which behavior is conditioned by organic structure.*[10]

[10] By structure is meant relatively permanent systems of energy patterns, called 'organs.'

Seventh, one more alternative may be examined. Are *tendencies* toward certain forms of behavior inherited? Again difficulties arise, for granting a tendency to behave in a certain way supposes that the act has commenced, that it is already in existence and about to unfold. For example, when a person remarks that he 'tended' to arise from his seat he means that he actually began to execute the act; he implies the entire performance in incipient form. Introspection shows that he anticipated the *completed* act; it was not the beginning of the act which he 'tended.' Moreover, 'tendency' as an explanatory concept violates the principle that an act begins when its end has been established, and not before. All of this means that the notion of tendency, like the notion of instinct, assumes everything which it is supposed to explain. The same difficulty is encountered in employing the concepts capacity, ability, and faculty, as explanations.

To give a few simple examples of the points that have just been emphasized, how confusing it would be to presuppose inherited pathways in order to explain why a bird selects a piece of straw for its nest? If straw is not available the bird uses string. In fact it may use hair, strips of cloth, flexible twigs, grass or what not. The necessity arises, therefore, of postulating a tremendous variety of pathways equipping the bird for an indeterminate number of emergencies! Moreover, the assumption of inherited tendencies in order to explain the selection of particular materials for nest building merely repeats the dilemma. A preferable hypothesis will interpret these activities as the products of specialized organs: eyes, bills, feet, wings, and the like, together with a nervous system developed to the extent that the animal intelligently perceives those objects and situations which its bodily structures permit it to handle. In other words, the nervous system as a whole makes possible configurational responses involving the use of those organs which the animal possesses. *The organs and the nervous system controlling their use have developed as one organic whole.*

Assuming, therefore, that so-called inherited or instinctive behavior is conditioned by *organic structure,* how did it happen, when it became necessary for the hatching of eggs, that

birds hovered over them instead of leaving them in the sand as their reptilian ancestors had done? How did it happen that as brooding became necessary birds developed higher body temperatures, thus imparting the heat necessary to guarantee growth of the embryos within? In answering these questions it may be supposed that in the course of evolution birds developed a complicated and organized structure consisting, *first,* of feathers, *second,* of a circulatory system which maintained a higher body temperature at all times, *third,* of a glandular system that upon the proper internal stimulation produced a fever, and *fourth,* a nervous system so integrated with the body as a whole, and so matured that birds *exhibited a behavior in which the eggs became a goal for the response of brooding. It is important for this theory to regard all these as various aspects of one unified structure, which not only evolved together but also produced eggs which would hatch only with incubation.*

In a similar way we may explain the migration of birds, the hibernation of animals, burrow digging, the feigning of the opossum, the fluttering of the mother partridge when an intruder disturbs her flock, and the devotion of the human mother for her child. In each case there is a unified system of specialized organs including a nervous system of a sufficient degree of maturation to permit a given level of insight and the execution of specialized performances. The specialized organs account in part for specialized responses to such stimuli as temperature, odors, a ground environment, and materials for nest building. A nervous system as a whole, matured to the right extent, conditions the insight shown in the use of these specialized organs. This view avoids the inconsistency and vagueness of inherited tendencies, and throws us back to organic structure for a final explanation.

Importance of the History of the Instinct-Emotion Problem. A lengthy discussion has been devoted to the history of the instinct-emotion problem because of its fundamental importance for psychology in general. In fact, whatever position is taken with respect to this problem colors one's concept of the entire field.

First, there is involved the question, what are the types

of stimulus-patterns which occasion emotive behavior? There has been a persisting inclination to regard situations that hinder the organism's activities on the one hand, or facilitate them on the other, as outstanding conditions. As everyone knows by observation an individual becomes angry when his actions are thwarted, or when something prevents him from satisfying his desires. Conversely, he experiences pleasure when circumstances assist him in the execution of his plans and in the fulfillment of his wishes. These notions imply that behavior is directed toward an end, and permits the possibility of regarding emotion as a tension that demands resolution toward a goal. There is nothing as yet that conflicts with the configurational hypothesis and the law of least action.

Second, another fact recognized long ago, namely, the importance of the internal organs for emotive behavior, was interpreted in a way that incurred numerous difficulties. Here were the physical organs, unquestionably associated with a 'state of mind' called emotion. The problem of the functioning of these organs finally expanded to the problem of instinct which as a physical process was considered entirely divorced from the emotional or mental process. The implicit dissatisfaction with this conception can easily be seen in the numerous and varied efforts to bring the two opposed activities together. (Darwin, James, McDougall.) Implicitly it is also an argument for the assumption held in the text, that behavior is exhibited only by the organism-as-a-whole. To divide the organism against itself as a physical and psychic creature destroys its unity, or at least makes it unintelligible. And if its unity is unintelligible it is impossible to reduce behavior to any fundamental principle, a situation which is in itself inconceivable. If the organism-as-a-whole is neither a physical nor a mental creature, but one whose so-called physical and mental activities are practical abstractions from the whole, nothing stands in the way of applying the same fundamental principles to any form of behavior that apply elsewhere in the world of discernible and predictable events. This is the position taken in the text, a position which is justified by the fact that dualistic attempts to solve the instinct-emotion problem have invariably been unsatisfactory.

Third, it was only natural that instinct, divorced from emotion, should have been regarded as a blind and mechanical process. Why not? It was physical, and physical events were supposed to be mechanical. Being mechanical it must be explained in terms of fixed, inherited pathways. For the same reason, the notion seemed adequate that any instinctive act was to be explained in terms of its parts. The fact that one unsatisfactory hypothesis thus led to another was sufficient ground for abandoning the point of view altogether.

Fourth, the difficulties involved in a mechanical interpretation of instinct did not stop here; they led to the problem of inheritance. Circumstances then compelled the admission that what is inherited after all is organic structure, not behavior. Accordingly, the fundamental principle again suggests itself that an event is to be explained in terms of the conditions under which it occurs. This means that the conditions of emotive behavior reside in the structure of the organism and in its environment, not in inherited action or in inherited nerve patterns already fixed for action. This view permits an acceptance of the observed facts, long ago recognized, that the internal organs function in emotion. It also makes logically pertinent an intensive study of the environment, and all conditions that produce emotive behavior, especially those of a social character.

Fifth, should we search for the conditions of organic structure in the ancestry of the race we would be led into many unsolved problems. While evolution is admitted as a fact, it is not an explanatory principle, and the origin of variations is still a mystery. To be sure, germ cells from the male and female presumably carry determiners that to some extent direct the growth of various physical structures within the organism. Human beings, for example, do not develop into elephants or cabbages! But lest too much stress is laid upon inheritance as an explanation of bodily traits, reflect that the body is the product not only of oxygen and food but of environmental pressure patterns which condition the shape and symmetry of the body. It is possible that the environment both of the ovum and of the embryo, being very much alike in members of the same species, determines many of the traits

that have been attributed to heredity (see footnote, page 490, also 491).

Finally, we are led to a different working hypothesis free from the problem of inheritance. It is the view that by virtue of their structure the internal organs furnish an intra-organic stimulation sufficient to cause high powered tensions. Then, if emotive behavior is a process of resolving tensions we would expect it to be vigorous, and as everyone knows such is the case. Furthermore, it leads us to seek in the environment the types of situations which furnish the exciting stimuli.

The Problem of Feeling

History of the Problem of Feeling. A history of emotion would not be complete without a reference to *feeling,* a problem which has played an important part in the psychology of emotion. In the later seventeen hundreds the problem of emotion was confused by the growing belief that feelings of pain, pleasure, activity, relaxation, and many others constituted a special class of mental processes different in character from those experiences that were occasioned by the sense organs of vision, hearing and contact. These latter experiences belong to the class known as sensations. For example, Bonnet, a physiologist (1720–1793), distinguished feeling from sensation. The latter depended, he thought, upon the sense organs of the body, but the former resulted from central activities of the brain. Kant (1724–1804) insisted upon feelings as a unique type of mental process. There followed a wave of emphasis upon feeling, contemporary with the romantic movement in literature and philosophy; in fact the emphasis developed to the extent of basing all mental states upon feeling. The feeling tradition persisted until modern times and in its final form postulated pleasantness and unpleasantness as affective elements of consciousness. Not of least importance among the reasons why feeling became separated from emotion was precisely this historical tradition of searching for 'elements of mind.' Once mind had been analyzed into three faculties, intelligence, feeling and will, an element was found for each of them. The alleged element discovered for intelligence was

sensation; for feeling it was affection, and for will it was a so-called *conative* element. The conative element was supposed to be a unique awareness of mental action, a consciousness of the striving or progressing of one mental process toward and into another.

Wundt's Tridimensional Theory. Wundt[11] was the first experimental investigator to formulate definite conclusions regarding the 'feeling-element.' He abstracted three pairs of affective elements from 'consciousness,' each member of a pair being opposite in its meaning from the other member of the pair. They were (1) pleasantness and unpleasantness, (2) strain and relaxation and (3) excitement and calm. Royce[12] pointed out later that strain and relaxation were not affective elements as Wundt had defined them; they were muscular sensations definitely caused by bodily contractions and relaxations. Still later, Titchener[13] ruled out calm and excitement and placed them in the category of kinaesthetic sensations, but presented certain arguments in favor of regarding pleasantness and unpleasantness as affective elements.

Present Status of the Feeling Problem. Feeling is not a simple elementary experience in the sense that it can be reduced to a single quality of affection or sensation. Experienced under ordinary life conditions it is an unanalyzed reaction to a total situation, a reaction which characterizes the situation as pleasant or unpleasant, good or bad, something to be sought or something to be avoided. Basically, however, it is a matter of tension and relaxation.

Introspective data on feelings have differed, it is true, because the conditions of experimentation have not been standardized. Certain investigators have attacked the problem of feeling under the influence of one prejudice, another group has analyzed similar experiences in the light of a different point of view. It is to be expected, therefore, that results would conflict, for *when various observers define feeling too specifically from divergent standpoints it inevitably becomes a different phenomenon; in each instance, it is an experience*

[11] Wundt, W., *Outlines of Psychology.* Leipzig: Engleman, 1902.
[12] Royce, J., *Outlines of Psychology.* Macmillan, 1911, 177 f.
[13] Titchener, E. B., *Textbook of Psychology,* 1913, 225 ff.

obtained under conditions that are not comparable. It should be borne in mind that the feeling described by the introspectionist is not the process recognized in everyday life as feeling; it is a feeling altered by an analytical, introspective attitude and abstracted from the life situation that gives it meaning; it is feeling broken down. The abstracted products are not to be identified with the unanalyzed feeling. Nafe's [14] subjects, interested in making refined abstractions, reduced pleasantness and unpleasantness to pressure sensations, but the pressure was not the original feeling. Moreover, the cause of the pressure remains unknown. In the author's experience a necessary but not sufficient condition of feeling is a change in muscular tonus. The dominating quality of pleasantness is a relaxation-kinaesthesis and for unpleasantness it is a tension-kinaesthesis, but mere relaxation and tension in themselves do not constitute feeling. The feeling is the total reaction to the total situation, a mild variety of emotive behavior; and its causes are the same in general as the conditions of emotion.

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CHAPTER VII

EMOTIVE BEHAVIOR: METHODS OF IMPRESSION

Psychoanalytic Methods

Methods of Studying Emotive Behavior. Methods of studying emotive behavior fall roughly into two classes, the direct and indirect, or methods of *impression* and methods of *expression.* By the method of impression we mean the observing of emotive behavior directly in ourselves or in some other person. The evidence for the existence of the emotive response is of two kinds: In the case of self-observation it is a report of the observer; in the other case it is the noticeable character of the response and the kind of situation in which the response takes place. In the method of expression, evidence for the existence of the emotive response is sought in the results of chemical analyses and in records from various kinds of instruments which measure breathing, vasomotor changes, reaction times, alterations in the electro-motive force of the body and the like. The latter method will be studied in the next chapter. Ideally, both methods are used simultaneously for it is with the use of instruments of precision that measurements of emotive response, such as they are, can be made.

Psychoanalysis as a Method of Impression: Its History. Psychoanalysis is one of the outstanding methods of impression, for it depends upon the observer's own report of his emotional experiences. It developed as a means of coping with problems of abnormal behavior; consequently the reader must bear in mind that the emotive life uncovered by psychoanalysis is generally very intense

and unstable. In other words, the individual who is being investigated is *neurotic.* In the early nineties, a Viennese physician, Joseph Breuer, along with other physicians, was attempting to cure hysteria with the aid of hypnosis. He discovered that when forgotten experiences were recalled by the patient under hypnosis, and free expression was given to the feelings that accrued from these experiences, symptoms of the disease permanently disappeared.[1] A certain patient, for example, became unable to drink; no sooner would she touch her lips with a glass of water, than the impulse seized her to push it away. Under hypnosis she recalled how shocked she was that a dog, belonging to her governess, had been permitted to drink from a glass. The emotional character of the experience had been all the more intense because she abhorred this particular dog. But owing to social convention she had inhibited her feelings, and a semi-hysterical condition was the result. After recalling the incident under hypnosis and giving expression to her repressed emotions she awoke from the hypnotic trance able to drink.

A little later Freud made use of this discovery in treating patients whom he failed to hypnotize. When neurotic patients were unable to recall the previous experiences which had evidently brought on the hysterical condition, he would assure them again and again that if they would have confidence in him and would try, they could remember the source of their difficulty. He noticed, however, that in many instances the patients were struggling against themselves as if a force were opposing the recall. He then conceived of *repression* as a dynamic cause of the forgetting. After studying the types of experiences which various patients were barely able to recall he concluded that they were always those experiences that had been intensely unpleasant and which the patient *did not want to recall.* The next step in his reasoning was the conclusion that repressions were *defense reactions* against the unbearable experiences. He

[1] Cf. Mitchell, T. W., *The Psychology of Medicine.* London: Methuen, 1921.

discovered, further, that the repressions concerned experiences incompatible with the moral and cultural standards of the patient. He concluded finally, therefore, that repressions were conditioned by the ethical attitudes and taboos of society and did not occur in individuals who were unintelligent, or had no principles, or were not critical of themselves.

A Typical Freudian Case. About this time Freud treated a young girl who had fallen in love with her brother-in-law. Shortly afterwards the sister died and at her bedside the thought, Now he is free and can marry me, flashed through the patient's mind. The thought was horrifying and although she forgot that such an idea ever occurred to her she fell ill, later, with hysterical symptoms. Under Freud's treatment she recalled her desire to marry her brother-in-law, relieved herself of the inhibition and according to the story, recovered.

Freud's Emphasis Upon Sex. Many of the repressed emotional responses which seemed to cause nervousness and hysteria were apparently sexual in character. Hence Freud drew the conclusion that the primary wish which brought the individual into conflict with social standards was the *sex craving.* He interpreted this craving (libido) rather broadly to include, (1) auto-sexual craving or self-love, (2) homosexual craving, or love of other persons of the same sex, (3) incestuous craving, or love for persons of the opposite sex within the same family, (4) sadistic and masochistic craving or love of sexual cruelty and pain and (5) exhibitionistic craving, or love of sexual display. These cravings commence, he thought, in childhood and produce conflicts as the individual develops and finds it impossible to express them in conventional society.[2] According to Freud, then, the sexual cravings which cause trouble are often 'perverse' in their nature.

Jung's Theory. Jung,[3] a student of Freud, interpreted the notion of libido more broadly to mean a life-urge that was expressed in other activities as well as the sexual. Accord-

[2] Cf. Bridges, J. W., "Psychoanalysis, a Contribution to the New Psychology." *Public Health Journal,* 1923, 1–7. Quoted by Taylor, *Readings in Abnormal Psychology and Mental Hygiene,* 112 ff.

[3] Jung, Carl G., *The Theory of Psychoanalysis.* Nerv. and Ment. Disease Publ. Co., 1915.

ing to him this libido manifests itself on the one hand in *progression,* a striving for differentiation, new activities and the overcoming of obstacles. On the other hand it reveals itself in *regression,* a slipping back to the undifferentiated condition and irresponsibility of infancy. In his view conflict becomes a struggle between the two trends; the neurotic person is one who has regressed to infantile modes of behavior.

Adler's View. Alfred Adler,[4] another student of Freud, interprets the fundamental drive in human life as a desire for power and security. Then an actual physical inferiority or an imagined inferiority induces attempts to compensate. If the compensation is unsuccessful the unintelligent patient shows signs of degeneracy. The genius, however, finds relief by altering his personality and by controlling his environment to suit him. The neurotic individual resolves the difficulty by excessive day-dreaming, by exhibiting peculiarities of conduct and by attaining power through illness.

The Purpose of Psychoanalysis. The purpose of psychoanalysis, whatever the underlying theory of the conflict, is to uncover the forgotten causes and to permit the subject to express his inhibited emotions. The apparent causes are then explained to him; he is introduced to his own personality and in most cases is greatly helped if not altogether cured. The technique is but another example of suggestive therapeutics in which new and appropriate motives for behavior are substituted for the old and troublesome ones. The final aim is a rehabilitation of the patient's emotional life.[5]

Methods of Psychoanalysis. (1) Dream-analysis. Because dreams appear more frequently in the life of the neurotic than of the normal individual, Freud considered them as expressions of unfulfilled wishes. He presumed that these wishes emerged from a subconscious mental level to the conscious level in a dream because at that time the normal inhibiting influences of waking life did not interfere. He explained the fantastic nature of dreams as the product of various dis-

[4] Adler, Alfred, *The Neurotic Constitution.* New York: Moffat, Yard, 1917.

[5] Cf. Hunter, *Introduction to General Psychology.* Second ed., Uni. Chicago Press, 1923, 92.

guising mechanisms which protected the wish and permitted it to be expressed unknown to the patient. Hence Freud emphasized dream-analysis as a method of exposing the disguised wish. The patient recalled a dream and with the content of the dream as a starting point he recounted various experiences. Then, in order to give the patient an insight into his condition the analyst used the information which the related experiences contained.

Frink [6] gives the following illustration of a dream-analysis: "An acquaintance of mine once dreamed that he was kicking a skunk and that that animal, instead of emitting its usual odor, gave off a strong smell of Palmer's perfume.

"In discussing this dream with me the dreamer, whom we may call Taylor, was reminded by the idea of Palmer's perfume that he had been employed as a clerk in a drug store at the time the dream occurred. This brought to mind the following episode which, as will readily be seen, was what gave rise to the dream. There had come to the drug store one day a man who demanded ten cents' worth of oil of wormseed, and, as this drug is not classed as poison, Taylor sold it to him without asking him any questions. The man went home and administered a teaspoonful of the oil to his six months baby. The child vomited the first dose, a second was given, and thereupon the child died. Then, instead of taking the responsibility upon his own shoulders, the father sought to blame Taylor for the child's death. The town in which the occurrence took place was a small one and in a day or so most of the inhabitants had heard this very untrue account of the affair. Then Taylor, who was naturally very unwilling to be thus exposed to public censure, sought to defend himself by setting forth *his* version of the matter to every customer that entered the drug store. In a few days the proprietor, annoyed by this constant reiteration, said to him: 'Look here, Taylor, I want you to stop talking about this affair. It does no good. The more you kick a skunk the worse it stinks.'

"That night Taylor had the dream I have related . . .

[6] Frink, H. W., *Morbid Fears and Compulsions.* New York: Moffat, Yard, 1918, 99. Quoted by permission of and arrangement with Dodd, Mead and Co.

By the proprietor's command Taylor had been robbed of the only means at his disposal for squaring himself with the public, and in consequence he went to bed that night very much worried and disturbed. Though he dropped off to sleep, these tensions persisted sufficiently to disturb his rest. He therefore dreams that he is still kicking the skunk but without any unpleasant results, for it has a sweet smell instead of an evil one. In other words, the meaning of the dream is that he continued to defend himself and that good rather than ill came of it."

Discussion of Dream-analysis. Dream-analysis, however practical, can hardly be called a scientific method for there is no possibility of verifying the interpretations. The dream given above might have been interpreted in a different fashion by another analyst and no one would have been the wiser. There is no right or wrong interpretation for there are no standards. Nevertheless, some psychoanalysts regard certain events in dreams as definite symbols of specific unfulfilled wishes. If a woman dreams of seeing a man riding a horse it is interpreted as a symbolic expression of a wish for sexual intercourse, the horse symbolizing the dreamer. Another alleged dream symbol is the loss of a tooth, which in women is said to denote the wish to have a baby and in men masturbation. Dreams of a sword, spear or snake are supposed to symbolize the male sex organs; fighting, dancing or climbing stairs signify coitus. But the psychoanalyst justifies his analysis of dreams by the results he obtains when he interprets their meaning to his patients. The validity of the method rests upon a pragmatic, not upon a scientific, basis.

Methods of Phychoanalysis. (2) The Free Association Technique. The free association technique has become popular as a means of reaching troublesome conflicts in the individual. The subject is asked to let his mind wander at will and to relate his thoughts as they appear. Sooner or later he will think of an event or word which he will hesitate to divulge. The psychoanalyst then attempts to break down this resistance. Many psychiatrists have found the simple expedient successful of conversing quietly and sympathetically with the patient, at the same time closely watching his re-

actions to questions and remarks that might prove significant. The main object of the interview is always twofold, that of encouraging the patient to unburden himself and to give him better insight into his condition. The first results in a beneficial effect known as *catharsis* or a relief from abnormal excitement. The second establishes different goals for the patient and prevents a recurrence of the excitement.

Jung [7] introduced the word-association method of detecting these inhibitions. He presented a list of words to the patient with instructions to respond with the first word entering his mind. He considered the following peculiarities of behavior as evidences of inhibitions:

1. Delayed reaction to a stimulus word, or to the one following it.
2. Unusual reactions: words given that are out of the ordinary.
3. Responding by repeating the stimulus word.
4. Perseveration of a response given to a previous word.
5. Superficial associations, such as rhyming or naming objects in sight.
6. No response.
7. Failure to make the same or like response on repeating the experiment.
8. Emotional and other responses such as clearing the throat, making gestures, stammering, sighing, weeping, laughing and showing surprise.

This method is not always adequate because the subject may be disturbed for purely superficial reasons, or he may be clever enough to suspect the purpose of the method and to inhibit the reactions that would betray him.

Association-reaction Method of Detecting Criminals. Attempts have been made to use the association-reaction method in the detection of the criminal on the theory that if he were guilty he would hesitate or give himself away in reacting to words connected with the crime of which he was suspected. The method, however, did not prove to be successful for several reasons. *First,* the subject would show delayed reactions to irrelevant words; *second,* he would make normal

[7] Jung, C. G., et al., *J. of Psy. and Neurol.*, 1904–1907, 1910. "The Association Method." *Amer. J. of Psy.*, Vol. 21, 1910, 219–269.

and unincriminating reactions to relevant words because he was not emotionally inhibited by his criminal acts; *third,* it was easy to refuse altogether to co-operate in the test. However, in situations in which co-operation can be readily obtained, such as in a laboratory experiment, the method frequently proves successful. Three students may be sent out of the room one of whom receives instructions to execute an unusual performance. The class then attempts from the reactions of all three to the 'keywords' to determine which student carried out the instructions.

The Valuable Influence of Psychoanalysis. In spite of the fact that psychoanalysts may have gone to extremes in their theories, their work contains a distinct contribution to the psychology of emotive behavior. *First,* it has definitely shown the importance of social causes in the origin of morbid fears, compulsions, peculiarities of conduct and even of the major neuroses like hysteria. *Second,* it has led to a frank and less prudish attitude toward matters of sex, for the latter without doubt have been the source of numerous emotional maladjustments in human life. *Third,* it has proved that emotive behavior can be studied and controlled in its social setting, a procedure which the older psychology neglected. As a consequence of this neglect the older psychology made but few contributions to the scientific explanation of emotion. Obviously, knowing that most abnormal behavior is fundamentally an emotional maladjustment that is socially conditioned, ways and means can be instituted not only of curing but of preventing it.

Our modern introduction to the real problems of emotive behavior came then from work in abnormal psychology. Interest in this field soon spread to normal behavior in which dominant urges, so-called, play a similar but less exaggerated rôle. As a consequence we have a great variety of descriptive terms for emotive behavior, and have studied a great many kinds of reactions which hitherto went unnoticed. As a consequence also, we not only have a much better understanding of normal but of criminal behavior, degeneracy and insanity, especially those varieties of insanity which have no visible organic basis. Losses of memory, hallucinations, de-

lusions of persecution, dementia praecox, hysteria, multiple personality and other forms of abnormal behavior are now regarded as extreme attempts to resolve difficult emotional conflicts.

Conflicts arise, it is said, when the desires of the individual remain unfulfilled. It would be preferable to say that *tensions arise when goal-activities are thwarted.*

Ways of Resolving Tensions

Goal-activities the Inhibition of Which Produces Tension. Goal-activities the thwarting of which will almost invariably produce tensions in the individual may be classified as follows: (*a*) Caring for organic needs, such as eating, drinking and sleeping; (*b*) maintaining bodily comfort such as efforts to keep warm or cool; (*c*) activities leading to and including the sexual act; (*d*) activities resulting in self-protection, such as fleeing from danger and escaping painful situations; (*e*) social activities such as avoiding or seeking company with others, or seeking social approval and avoiding disapproval; (*f*) pursuance of interests such as hobbies, play and recreation. In general, of course, the thwarting of any purpose, even the inhibiting of any 'tendency' to be active, produces a tension.[8]

It is futile to attempt a scientific classification of these modes of behavior. They are too numerous, too much alike in that they are common to mankind, and yet quite different, varying in different individuals and in different social environments. Moreover, it is undesirable to call them 'urges,' because 'urges' are substitutes for instincts! To speak of specific urges exposes one to all the difficulties experienced in coping with the latter concept. But is it not legitimate to regard these tensions as *innate* or *inherent* in the individual?

Question of Inherent Goal-activities. We have seen how Thomas derives personality from the four 'inherent' desires: (1) for action, (2) for safety or security, (3) for response from others and (4) for recognition or appreciation

[8] Cf. Gates' list of dominant urges, *Elementary Psychology.* Rev. Ed., New York: Macmillan Co., 1928, 223 and 227.

from others (page 42). Many writers, for example Gates, list what they consider innate urges, while the psychoanalysts have defined desire for sex gratification, for superiority over others, and so on, as 'inherent desires.'

From the standpoint of the text none of these conceptions avoids the instinct dilemma; they engage in the pointless distinction between what is acquired and what is inherited response. Why should responses be any more *innate* than the flow of heat from a warm to a cold body? In the latter instance, *new patterns of motion occur under new conditions,* where the assumption of innateness would be utterly superfluous; action anywhere is to be explained in terms of the conditions under which it takes place. Indeed, no distinction is made between inherited and acquired action in physics! Actions of living organisms are as 'physical' as action anywhere, hence the theory of *innate* drives is a redundancy. These so-called drives are goal-activities, and these goal-activities are tensions demanding resolution, not because of their heritable character or innateness but in accordance with a fundamental physical law and its conditions, the law of least action.

The instant an emotional tension arises, the human being endeavors in various ways to secure relief. These methods of resolving tensions, particularly in social situations, constitute the material for discussion in the next several pages and are popularly known as 'defense mechanisms.'

Methods of Resolving Tensions: Compensation. Compensation is a broad term referring to a multitude of ways in which tensions are resolved. As the name suggests, its outstanding feature is the establishing of harmony or equilibrium in the individual by setting up counter tensions or counter attitudes. It is a case of least action occurring in the form of 'action and reaction.' The following examples should make the point clear. (1) A certain person is always inviting criticism of himself, perhaps of his business methods, his sermons or his lectures. But if he actually obtains what he requests he becomes very much distressed, for it is flattery he is seeking instead of criticism; and *he probably knows it but he would prefer to think otherwise.* By this apparent desire for criti-

cism he is compensating for an egotism which he finds unpleasant. (2) The child who boasts about his exploits and how he could 'lick' all his comrades in the neighborhood proves a coward when his bluff is challenged; he is compensating for cowardice. For a similar reason a person *calls attention to some unsatisfactory feature of his work or personality of an insignificant nature in order to attract attention to its perfections.* (3) A man of small stature compensates for a feeling of inferiority by acquiring a 'loud masterful voice or a hard, even gaze.' (4) The mother who dreads the approaching time when her young son will outgrow his dependence upon her shows an undue amount of concern for his welfare. She denies him permission to go swimming for fear he will contract a cold or drown, while secretly she wishes that a catastrophe would befall him, for her mother-craving would then find gratification in the tender care with which she could minister to his needs.

Introversion. Introversion is another tension-resolving process involving numerous modes of behavior. The individual avoids an unpleasant conflict either between different parts of his own nature or between himself and an apparently cruel social environment. Psychoanalysts frequently call introversion a 'flight from reality' because it is a substitution of imaginary for many of the actual conditions of life. The general characteristics and interests of the introverted individual have already been described (page 43). Freyd's[9] list of responses, which is partially reproduced below, presents this type of personality in greater detail.

1. Blushes frequently; is self-conscious.
2. Takes up work which requires painstaking and delicate manipulation.
3. Hesitates in making decisions on ordinary questions that arise in the course of the day.
4. Introspects; turns his attention inward.
5. Depreciates his own abilities, but assumes an outward air of conceit.
6. Is critical of others.

[9] Freyd, Max, "Introverts and Extroverts." *Psy. Rev.*, Vol. 31, 1924, 74–87.

7. Is extremely careful about the friends he makes; must know a person pretty thoroughly before he calls him a friend.
8. Feels hurt readily; apparently sensitive about remarks or actions which have reference to himself.
9. Is outspoken; says what he considers the truth regardless of how others may take it.
10. Is absentminded.
11. Prefers participation in competitive intellectual amusements to athletic games.
12. Is a poor loser; considerably upset and indisposed after loss of a competitive game.
13. Indulges in self-pity when things go wrong.
14. Day-dreams.
15. Expresses himself better in writing than in speech.
16. Is a good rationalizer.
17. Is conscientious.
18. Resists discipline and orders.
19. Is sentimental.
20. Is strongly motivated by praise.
21. Is selfish.
22. Is suspicious of the motives of others.
23. Is effeminate (if a man).
24. Is a radical; wants to change the world instead of adjusting himself to it.

Day-dreaming as a Form of Introverted Behavior. Morgan[10] tells of a lad in the elementary schools whose teacher ridiculed him before the class and called him stupid for not having his lesson. After this incident he showed exaggerated symptoms of day-dreaming and became poorer than ever in his studies. Finally he related this significant day-dream to an older person who had befriended him. He imagined himself in a battle with a band of Indians. One by one his comrades fell around him until finally, with a rush he courageously charged the enemy and had succeeded in routing them when, alone, he fell severely wounded. Just then reinforcements arrived from home but the Indians had vanished. He was carried back on the shoulders of his comrades and the entire village turned out to greet him. First among those to offer praise was the school teacher who knelt

[10] Morgan, J. J. B., *The Psychology of the Unadjusted School Child.* New York: Macmillan, 1924.

down and implored his forgiveness for thinking that he was a stupid good-for-nothing!

The incident illustrates how in day-dreams the dreamer always plays the part of a hero, and how the events which occur in the dream are those which resolve tensions. Who has not pictured himself a hero in battle, on the football field, in debate, in concert, in the pulpit, in medicine, in business or what not? Everyone constructs a world about him to his liking, a world which gratifies his unfulfilled desires. In this way he avoids the intolerable experiences which the actual environment in his estimation holds for him.

In day-dreams, also, ambitions are born, plans are constructed and inventions are created. Accordingly, the person who never day-dreams is generally innocuous! On the other hand day-dreaming in its *extreme* form leads in children to a confusion between the real and imaginary worlds, also to pathological lying or at least to persistent habits of exaggeration. Carried to an extreme in unstable adults it may become a form of paranoia in which the patient has delusions of grandeur; he is Alexander the Great and has conquered the world, or he is Christ and has saved it.

Not only the conquering hero but also the suffering hero appears in day-dreams; the dreamer indulges in self-pity. Everyday occurrences of the suffering hero form of behavior are found in pouting, sullenness, refusals to eat and play, to wear a dress that is disappointing, and in indignantly leaving a party upon the suspicion of being slighted. In children behavior of this sort is common and can be handled best by ignoring the suffering hero! If the child who refuses his dinner finds that no one cares he will forthwith manifest all the symptoms of genuine hunger. In exaggerated forms the same behavior is found in delusions of persecution, acts of martyrdom, in the simulation of illness and even in suicide.

Identification. *Identification* is a form of introversion either of the conquering or suffering hero type in which the individual plays the rôle of a personality about whom he has read or heard. Harmless and normal cases are found in a child's play activities in which he imagines himself a doctor, a priest, a detective or an adventurer. But it is a different

matter when a young boy runs away from home and aspires to be a Jesse James! Dime novels and moving pictures very probably contain, therefore, an element of danger especially for the child who is unhappy at home.

There are many other ways in which identification is revealed in behavior. A person's house, his dog and his automobile assume character traits of their own generally like his. At least he sees in them virtues which he would like to have, or thinks he possesses, and these are generally superior to the virtues he sees in his friends' dogs or other possessions. Also, the community in which he lives and the institutions to which he belongs appropriate his virtues. The resident of a certain town experiences a glow of pleasure when a stranger informs him that he lives in a great and beautiful city. The dweller in the country resents any slighting remark about country manners. If a singer is assured that his voice is like Caruso's he swells with pride. The imitation of the great and near great and the readiness with which a person accepts their dress and manner as fashionable are processes of identification which permit him to feel some of the importance he ascribes to his superiors.

Rationalization. *Rationalization* is one of the most common of all the defense mechanisms. A man will sink deeply in debt to build an expensive home, but rather than admit the painful truth that he borrows in order to travel with his wealthier friends he reasons that he needed more room, that his old home was not healthful because of the drafts, or that he merely built the new one for an investment and to help business in the community. Likewise the smoker indulges in an extra cigar convincing himself that it will quiet his nerves; the student explains that he needed the exercise and therefore went canoeing instead of studying his lessons.

Projection as a Form of Rationalization. Rationalization frequently assumes the form of *projecting* the blame for an awkwardness upon some outside cause. For example, most persons prefer not to admit stupidity or that they are in the wrong. Through carelessness they run into the edge of an open door, but rather than to admit their awkwardness they become angry at the door and punish it for being open

by slamming it shut. When they make a poor drive in golf they blame the club; it was not properly balanced; if they could afford it they would buy a new one. The clumsy carpenter drives a nail in crooked whereupon he 'damns' the hammer. The bridge player makes an error, loses game, and justifies his mistake by quoting a rule which he is trying to make apply to the situation. The student receives an F in his examination and insists that the quiz was unfair or that the instructor could not teach.

The Sour-grapes Rationalization. The sour-grapes mechanism is another form of rationalization. The would-be social climber, thwarted in her ambition, despises the leading lady of the community. The defeated politician thinks after all that he is too busy to be a senator. Humble citizens of very little financial means condemn the aristocracy as social parasites; persons who lack forceful traits of character despise aggressiveness in others; the poor convince themselves that money is the cause of all evil in our present day civilization.[11]

Sublimation. Sublimation is a means of resolving tensions by releasing one's energies in the pursuance of highly ethical and approved tasks and vocations. Chivalry, for example, is said to be a sublimation of sadistic impulses. The bully at school who derives pleasure from beating and teasing his smaller companions may be made to divert his energies into being a dignified and trustworthy guardian of the school yard. The person whose sexual impulses are unusually strong and whose desires cause self-mortification diverts his energies into religious work, philosophy or art, in which his wishes may be symbolized and glorified. Sublimations of this sort are frequently overdone. For example, a morbid fear of pain and death may be diverted into a fanatic interest in Christian Science. A passion for cruelty may lead to an unreasonable stand against vivisection and a sex craving may result in a much overdone program for social welfare.

Regression. *Regression,* another tension-resolving procedure, refers to many varied activities. Generally it describes the substitution of a more primitive mode of be-

[11] See Gates, *op. cit.* 249 ff., for a statement of these and various other defense mechanisms.

havior for a less primitive one. Many cases of compensation and rationalization are in this sense regressive. Since most forms of regression involve a return to childhood interests and attitudes or to the interests and attitudes of primitive people, this type of behavior is *atavistic*. Adult participation in competitive games, in hunting and in fishing, are good examples of normal atavistic regression.

The Regressive Features of Religion. Much in religious behavior illustrates regression. The prevailing motive of Christianity is a regressive trend in which adults rely upon the domination, tenderness and protection of parents symbolized by the mother-God and father-God. The Old Testament God possessed the conventional father-attributes of the time; He was an angry and revengeful character. The New Testament God is a loving Father, and more feminine in character.

The regressive element in religion may be traced to the long period of human infancy with its dependence upon parental guidance. In later life when the adult confronts numerous perplexities he lives over again the helplessness and fear of his childhood and longs for the tender care which he then enjoyed; consequently the concept of God as a father or mother is attractive to him and he prays to this God for help in the same spirit that a child approaches his parents. Many hymns illustrate the same childlike attitude; in them human beings are 'protected by the shadow of His Wing' and are 'fed with the Heavenly Manna.' They are weak, lost and wandering; they require assistance; and the world is an unhappy place with escape only through death. The rebirth symbolisms characteristic of primitive religious ceremonies and myths, as well as the Easter story, owe their appeal to the regressive character of human nature. Mythical heroes are made self-perpetuating by a return to youth, a feat which is often performed in the act of overcoming an enemy and thereby gaining new powers and knowledge. Frequently the hero, entering into the enemy's body, comes out whole and with renewed life; in other legends the hero dies and is resurrected.[12]

[12] Wells, F. L., "Mental Regression: Its Conceptions and Types." *Psychiat. Bull.*, 1916, Vol. 9, 445–492. The intelligent reader will not find

Regression and Domestic Difficulties. Domestic difficulties frequently arise out of a regression of the husband to mother-love or of the wife to father-love. One or the other finds that married life is not what was expected; there is lacking the tenderness, sympathy and sacrifice characteristic of so many previous years of close family life. As a consequence either the husband or wife, who had probably been spoiled by too much attention, shirks the responsibilities of marital relations and slips back to a more comfortable 'level.' The husband's mother, jealous of her son's affections for his wife, not infrequently widens such a breach by attempting to retain a guardianship over her son.

Kempf's Physiological Theory of Defense Mechanisms and of the Functional Neuroses. *These various defense mechanisms, so-called, have thus far been classified only superficially as processes of compensation, rationalization, and so on.* Kempf [13] has gone further and advanced an interesting theory which seeks to bring them into relation with the physiological activities of the individual. The older psychology was largely written with the implication that the conditions of physiological activity were exclusively physical, and that mental hygiene was a matter of acquiring new and proper habits. Kempf, however, stresses *social situations as important regulators of man's physiology,* and in this he has obviously emphasized an important fact. A *person's whole physiology is frequently ruined by the loss of his social status!*

Social situations profoundly affect the individual by causing widespread organic changes within the body through the medium of the *autonomic* nervous system (see page 214), a system of nerves which regulates digestion, movements of the alimentary tract, breathing, heart action, the sex organs and the various glands of the body. The nervous system which controls the external muscles of the body is the servant of the autonomic; it is through this 'external' system, with its sense organs of sight and hearing, that the autonomic receives most of its stimulating influences. These influences set up autonomic tensions, and in turn, the tensions spread to the

in these interpretations anything which detracts from the moral value of religious beliefs.

[13] Kempf, Edward J., *Psychopathology.* St. Louis: Mosby, 1920.

external system, causing the organism to behave in such ways as will bring relief.

Whenever the human being is under an autonomic strain, his modes of behavior are always dominantly emotive. The end of any such mode of behavior is a return to autonomic equilibrium, but if the tensions are too severe, such a return to equilibrium means a relative disintegration of personality. If in this way the difficulties are too persistent and exaggerated they are called *neuroses,* of which there are three general groups.

First, there are the *suppression neuroses* which are characterized, according to Kempf, by persistent ideas, preoccupation, unpleasant dreams, insomnia, inaccuracy in performing tasks, errors of speech, headaches, dizziness, digestive and circulatory disturbances. These neuroses are the initial efforts of the individual to resolve his tensions or in other words to satisfy a wish, a sex craving, a desire for power or a desire for appreciation. The tensions become extreme when the individual's normal and voluntary attempts at adjustment fail, such as efforts to change his attitude or to ignore the situations which give rise to the tensions. When the suppression is complete, the subject's condition is abnormal, as in hysteria. Suppose, however, that the normal individual is *unsuccessful* in suppressing his autonomic tensions. Then fears arise and a *second* type, called *compensatory neuroses,* develop in the form of extreme egotism, boastfulness and general heightened activity involving the glands of the body (especially the thyroid). Eccentric personalities are the result, even various forms of insanity in which illusions of grandeur play a large rôle. *Third,* there are *negative* attempts to compensate which Kempf calls *regression neuroses.* The subject ceases to regard social conventions and what others think of him; he resolves his tension by avoiding the goals that conflict with his desires. He reverts to childhood; abandons the fight. Having thus rid himself of inhibitions he exercises his indulgences anywhere as unconcerned as a child. In extreme cases, he may develop dementia praecox, a form of abnormal behavior in which carelessness and lethargy are practically complete.

Summary. We have seen how the psychoanalyst abstracts from the total behavior of the individual those activities which we call emotive and finds in them symptoms of conflict between various tensions. Indeed, conflict is the rule in life rather than the exception. However, individuals show wide differences in their ability to resolve their tensions and at the same time continue to behave normally. Functional insanity and the neuroses occur when the individual is unable fairly and squarely to face the causes of conflict and to perceive the goals which would lead to a normal resolution of tensions. These failures occur in persons of less than normal nervous stability, although we do not know exactly what such a statement means from a physiological standpoint. In terms of behavior it means either a loss or an exaggeration (distortion) of emotional reactions. Stimuli come to have either a less or a greater effect on the subject than is normally the case. Nervous instability also means, in many instances, that the patient is incapable of perceiving the real cause of his tensions because he has already convinced himself through compensation, rationalization or other defense reactions, that a different set of causes prevails. In the meantime maturation has taken place to such an extent along specialized lines that re-education is a long and difficult process, and perhaps impossible.

Laboratory Methods of Impression

Let us turn to a more refined method of impression than psychoanalysis, namely, introspective analysis as such. This method has not yielded results that lead to prediction and control; it contributes to the body of facts which are considered purely descriptive.

It will be remembered how James and McDougall construed emotion as something apart from behavior. James said it was the consciousness of the organic reaction elicited by an exciting stimulus; McDougall defined it as the psychic aspect of an instinctive response (see page 166). So too, most of the earlier psychologies implied that the fundamental problem of emotion was to analyze it into its component mental processes. These mental processes can be abstracted from

emotive behavior and viewed as objects of investigation in themselves.

Introspective Analyses of Emotion. Introspective analyses of emotion have been made in the past by psychologists who defined their science as a study of the mind. Their professed purpose was to analyze the emotional 'consciousness.' This abstraction is neither to be identified with nor explained as a separate aspect of the emotive behavior found in daily life. The emotive 'consciousness,' like any other 'consciousness,' will not stand up under observation. Once it is abstracted from the emotional response as a whole, a feat impossible for naïve observers, it breaks down into processes of a 'simpler' order than ordinarily occur in the mental life of untrained subjects. Moreover, in the laboratory the observer greatly limits his responses. If it is anger he neither strikes nor raves; if it is fear he does not run. He must forget the exciting stimulus; he must sit still and concentrate upon his experiences. Obviously under these conditions it is difficult to arouse genuine emotive responses, but if the subject can observe them quickly enough after the exciting stimulus is given he can describe introspectively whatever the method succeeds in producing.

The following descriptions were obtained by observers in the psychological laboratory immediately after the arousal of the emotive responses. The first introspection describes fear when the subject expected a horrible object would be placed in his hands. The subject was blindfolded.

Anticipated that the stimulus would be of an emotional character. Rising tenseness all over the body. In terms of visual imagination and inner speech, tried to anticipate what the experimenter was going to do. Uneasy all over; couldn't get into comfortable position in the chair; jerky tensions in chest, face, throat, legs and abdomen; uneasy tenseness as if ready to jump off the chair at the least provocation; visually imagined tiny snake in my hands; little fellow with its tongue sticking out; then cringing movements of the arms and shoulders; shrugging, which I interpreted as loathing; developing contractions in back of mouth cavity and sinking of diaphragm; mixture of temperature and pressure sensations over my trunk and along my back; cold chill. Then visualized an oyster lying in my hand, then a crab; then

an imaginary pain in my second finger as if crab had pinched it, together with coldness and clamminess imagined in palm of my right hand; became still more tense; felt heart throbbing in my chest; wave of warmth spread over face; felt pressure of blood underneath skin of the face; breathed rapidly. Whole body contracted and drawn together; shrinking from the ordeal that was to come; sudden attempt at self-control . . . felt hot all over and momentarily held breath. Interpreted all this as fear and loathing. No single experience constituted either the fear or the loathing. No interpretation of the experience as unpleasant.

2. The observer was very fond of roses. Here the stimulus was a bouquet of roses which he was instructed to smell.

The olfactory sensation (odor) developed very suddenly to its maximum intensity; noticed at first the spicy quality, then the perfume-like aroma; the rose quality itself was not analyzed at the time. Breaking in upon these olfactory experiences were the muscular contractions of inhaling, and an intense wave of pleasure. Pleasantness consisted of, (1) relaxed feeling of the facial muscles, especially about the eyes and mouth (relaxation of these muscles gives a peculiar quality, not like relaxation of the arm or other body muscles and it is this quality which stands out in the pleasant experience). (2) A series of verbal remarks made to myself, 'Oh, how exquisite; how delightful.' (3) A most intense contraction of the diaphragm; a sinking sensation as if there were a dropping of organs inside. The quality of this latter experience was that of a strain. The whole experience startled me because I was not expecting it; it is exactly the same sort of experience I have in fear; also have experienced it in strong admiration for something, and in caressing my child. (4) General background of muscular relaxation about the trunks and legs. (5) Tendency to exhale with a sigh. The intense pleasure is the *total experience.*[14]

Summary of Introspective Data on Emotive Behavior. Large numbers of these descriptions given in the minutest detail by many observers in a variety of situations are necessary before adequate generalizations can be made as to the nature of 'abstracted' emotion. But in the absence of any more detailed information than is given above, we may draw the following conclusions: Considered as a mental process,

[14] From a study by Miss Cecile McAlister, abstracted in *Psy. Bull.*, Vol. 23, 1926, No. 1.

emotion is a very complex experience reducible roughly to three varieties of content. The *first* is characterized by an apprehension of the stimulus-situation as dangerous, disgusting or what not; the subject perceives the stimulus and interprets it. He may also find a number of mental processes concerned with avoiding the exciting situation. He may think suddenly how to prevent crashing into an automobile. If he sees a snake at his feet he imagines himself in the last stages of tetanus, and in this way anticipates what might happen if he were bitten. We may call these the interpretive features of emotive behavior. *Second,* there are numerous bodily sensations depending upon muscular tenseness, incipient movements, changes in circulation and breathing, action of the sweat glands and an inhibition of salivary secretions. These sensations were designated by James as the emotion proper. *Third,* there are vague kinaesthetic and pressure experiences which many observers have had difficulty in describing and which earlier investigators thought had no special bodily reference. These are the so-called feelings, namely, pleasantness and unpleasantness.

Quantitative Impression Methods of Investigating Feeling and Emotion: The Method of Paired Comparisons. There is no procedure by means of which feeling and emotion can be measured with any degree of accuracy. On the other hand, the relative intensity of feeling can be estimated when one object is paired against another. If large numbers of objects such as colors are compared, the relative feeling value of each color can be roughly determined quantitatively.

Suppose the problem is to ascertain the relative feeling value of the saturated colors, (1) Red, (2) Yellow, (3) Yellow-green, (4) Green, (5) Blue-green, (6) Blue, (7) Violet and (8) Purple. To guarantee that each color is compared with every other the accompanying chart is used. (Figure 11).

There are 28 comparisons to be made under the instructions, which of these colors is the more pleasant or unpleasant? Roman numerals indicate the colors and Arabic numbers represent the number of the comparison. The position of the

Arabic number, 1, shows that it is a choice between colors I and II, or red and yellow; 2 is a choice between yellow and yellow-green and so on. This procedure offers the added advantage of preventing the subject from using the same color more than twice in succession; thus he avoids the possibility of altering the feeling value of any one color through habituation. The color chosen in each comparison can be indicated within the square containing the comparison-number. The number of times each color is preferred to its companion can easily be counted and a profile curve plotted showing the observer's color preferences. The frequency of a given preference measures the relative feeling value of that particular color. Figure 12 shows a typical curve. Notice that the pure, saturated colors were preferred to the tints and shades. Purple seemed to be the favorite color; light yellow was the least pleasant.

		I	II	III	IV	V	VI	VII
		R	Y	YG	G	BG	B	V
II	Y	1						
III	YG	2	3					
IV	G	14	4	5				
V	BG	15	16	6	7			
VI	B	23	17	18	8	9		
VII	V	24	25	19	20	10	11	
VIII	P	28	26	27	21	22	12	13

FIG. 11. CHART FOR USE IN PAIRED COMPARISON EXPERIMENT.

After the method used by Titchener, *Experimental Psychology*, Macmillan, 1909, Vol. 1, Pt. 1, 93. The method is adaptable to any number of colors and to many other kinds of material where large numbers of objects are paired with each other for the purpose of making judgments.

Meier's Study of Aesthetic Values. Meier[15] has recently made an interesting and bold attempt to measure aesthetic judgment in the hope that eventually he might discover a measure of talent in art. In so doing he has attempted to measure the pleasure and displeasure derived from looking at aesthetic objects. He used fifty dual-choice themes, as illustrated in Figure 13, and ten multiple-choice themes. In the former the observer was to choose the better picture with respect to a certain detail and in the latter he was to choose the best out of five variations. The judgment of the original painter was the standard of correctness. There were four groups of observers: (1) high school students, (2) college undergraduates, (3) college art students and (4) members of

[15] Meier, N. C., "Aesthetic Judgment as a Measure of Art Talent." University of Iowa Studies, 1926, Vol. 1, No. 19; Psy. Mon., 1928, No. 2.

an art faculty. College undergraduates averaged eight points above high school students; college art students averaged five and one half points higher than unselected college students, and the art faculty averaged six and one half points above art students. The scores for each group showed a tendency to scatter according to the normal frequency curve. It would seem, therefore, that these preliminary experiments promise a method for predicting the probabilities of success in art.

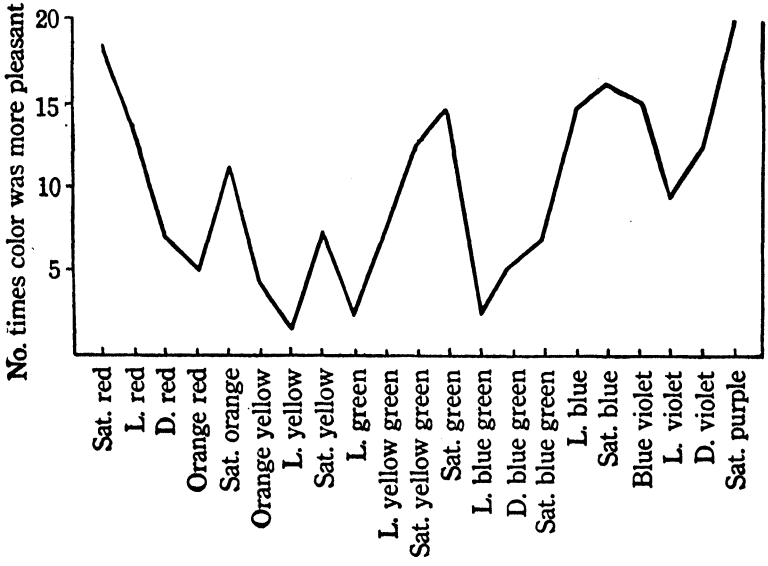


FIG. 12. SAMPLE CURVE OF COLOR PREFERENCES.
Sat. means saturated; *L* means light and *D* means dark.

Feeling Value of Advertisements: Order of Merit Method. A simple but rough method of measuring the feeling value of objects has been used especially in estimating the appeal of advertisements. This is known as the *order of merit method.* Several advertisements (other objects may be used just as well) are arranged by the observer in order of preference. The most effective is assigned the value of 1, the next pleasing is given the value 2, and so on; then the rank values are averaged. In this way the likes and dislikes of a group of people can be measured in one experiment.



FIGURE 13. THEMES USED IN MAKING AESTHETIC JUDGMENTS (MEIER)

Upper theme: Which picture possesses the better balance because of the position of the women?

Lower theme: In which picture does the background produce the better total effect?

Conklin's Scale of Values Method. Conklin[16] has recently modified the order of merit method. He did not ask his observers to assign a rank value to a given object, leaving them to decide what merit they should attach to the value of 1 and to the value of 2 and so on. He employed a scale of values in which the rank of 1 meant greatest possible pleasure, 2 very great pleasure, 3 great pleasure, and so on until the rank of 6 was reached which signified indifference; 7 meant slightly unpleasant, 8 more unpleasant, and so on to

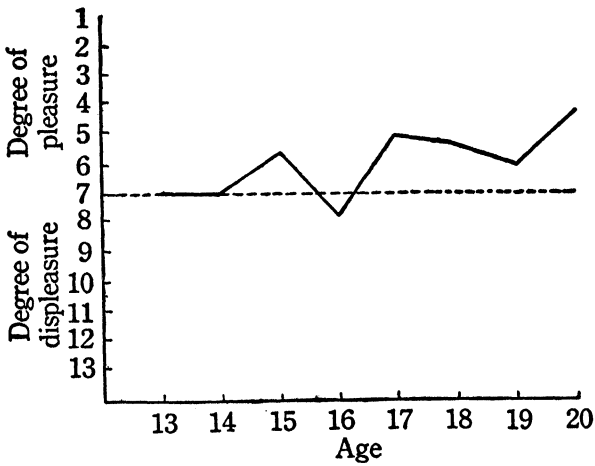


FIG. 14. THE RELATION OF AFFECTIVE VALUE TO AGE (Conklin).

The curve shows a gradual increase, with the ages of the subjects, of the affective value of the proposition, "Stand by some principle you believe in, even though everybody laughs at you."

13 which symbolized the greatest possible displeasure. Then the observer was asked to evaluate a given object, a proposition, a joke or a picture in terms of this scale. By testing individuals of different ages from ten to maturity, Conklin obtained curves of likes and dislikes for a variety of situations and ascertained how feeling reactions in people changed with mental growth. Figure 14 shows the affective value of the proposition, 'Stand by some principle you believe in, even though everybody laughs at you.' The curve, based upon

[16] Conklin, E. S., "The Scale of Values Method for Studies in Genetic Psychology." *Uni. of Ore. Publ.*, Vol. 2, No. 1, 1923.

1700 returns, indicates that the proposition becomes slightly more pleasant as people grow older. Not only pleasure and displeasure may be investigated in this way but also beliefs and disbeliefs, and attitudes of certainty and uncertainty. Figure 15 shows curves for belief in the superstition, 'Finding a four-leaf clover brings good luck.'

Recently there have been several investigations by the impression method with facial expressions as material. Using on 716 subjects the Boring-Titchener modification of the

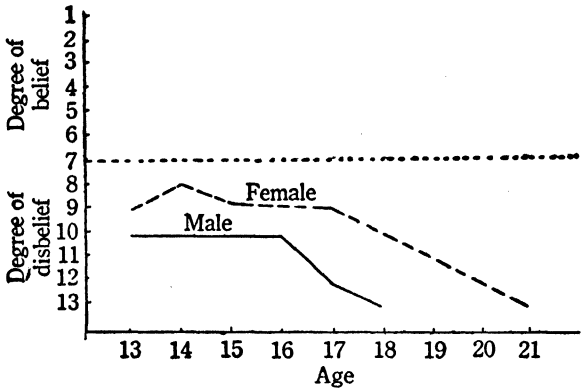


FIG. 15. THE RELATION OF BELIEF TO AGE (Conklin).

The curves show the gradual decline of belief, with the subjects' ages, in the superstition, "Finding a four-leaf clover brings good luck."

Pederit model for demonstrating facial expressions, Buzby[17] found, (1) that the eye and brow were safer sources of impression than the mouth and that (2) the horrified, disdainful, disgusted and bewildered expressions were reported with a higher degree of accuracy than anger and dismay. Several investigations of like nature have recently been made with the use of photographs. For example, Dunlap[18] studied the relative importance of eyes and mouth in the portrayal of emotion. He photographed several individuals at the time they were made to react emotively in different ways. He

[17] Buzby, D. E., "The Interpretations of Facial Expressions." *Amer. J. of Psy.*, Vol. 35, 1924, 602–604.

[18] Dunlap, Knight, "The Rôle of Eye-muscles and Mouth-muscles in the Expression of Emotions." *Gen. Psy. Mon.*, Vol. 2, No. 3, 1927, 196–233.

then cut their photographs into lower and upper halves and paired the eye expression of one emotion with the mouth expression of another. When he showed the altered photographs to a group of judges he found that the mouth usually dominated the facial expression. A weeping mouth made laughing eyes take on a 'weeping expression' and *vice versa.* Similar results were obtained from other emotional expressions. But owing to the fact that many expressions are not judged correctly when there is no mutilation the method has only a limited usefulness.

Retrospect on Chapter VII. The study of methods of impression introduced us to a great many facts but to no exact formulae by means of which emotive behavior could be predicted and controlled. This is because we are still dealing with modes of response too variable and complex for exact predictions. Nevertheless, by applying the information that is available many forms of abnormal emotive behavior can be corrected. Indeed, our knowledge of human nature has been increased enormously by means of impression methods and some progress has been made in attempts to measure feeling.

Our next problem is to study the more exact methods of measuring emotion. The reader should bear in mind, however, that in dealing with behavior, exactness of measurement depends upon isolation of the process to be measured. Our procedure will perhaps answer the question already mentioned several times: Do we find in the organic structure of the organism the outstanding condition of emotive behavior? If so, emotive behavior need not be regarded as innate or instinctive, and the distinction between inherited and acquired behavior breaks down.

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CHAPTER VIII

EMOTIVE BEHAVIOR: METHODS OF EXPRESSION

Physiological Methods

Introduction. The organic and muscular features of emotive behavior can be isolated by methods of expression. The phrase, 'method of expression,' incidentally, originated in connection with the belief that the expression of an emotion was to be distinguished from the emotion proper. But, as we have seen, this distinction is unnecessary; the bodily movements involved in anger, flight, seeking, avoiding and laughing, are as truly features of the emotion as the abstracted mental processes known as affection, feelings and sensations. Emotion can be regarded as a mode of behavior of the organism-as-a-whole; it is a response from which, by setting up the proper conditions, either mental processes or muscular and organic activities can be abstracted. The conditions necessary for the abstracting of mental processes from the emotion are the conditions for introspection, namely, training in this type of observation, and establishing the proper goal. The conditions which lead to the isolation of the organic and muscular phenomena of emotion constitute the subject matter of this chapter.

The ancients were partly correct in associating emotion with abdominal organs and with the heart; James and Lange were not wrong in contending that vasomotor and other organic changes were prominent features of the emotive reaction. Indeed, these descriptions of organic changes furnished by the history of psychology suffered chiefly from the defect of incompleteness because of necessarily crude methods

of investigation. In recent years, Cannon,[1] with his associates, have demonstrated many of the numerous bodily processes that are involved in the emotive response. These investigators point out, first, the evidence from everyday experience and second, they present data obtained with the use of refined laboratory methods. Let us inspect these methods together with the resulting evidence.

Evidences of Organic Changes During Emotive Behavior: (1) The Effects of Pleasurable Anticipation of Food. Everyone has observed that his mouth waters at the sight of delicious food, especially during hunger. The salivary glands begin to secrete before food reaches the mouth and of course the secretions continue as long as one is eating. Likewise, gastric juices flow from the lining of the stomach while one is chewing and swallowing. Indeed, digestional secretions are stimulated along practically the entire alimentary tract. The fact that seeing and smelling food initiates them led Pawlow, a pioneer worker in this field, to call them *psychic secretions.* Pawlow [2] became interested in these psychic secretions and measured them under varying conditions in dogs. His method consisted, first, of making a side pouch in the dog's stomach separate from the main chamber. Then he inserted a tube into the pouch, causing the gastric juices to drip upon a delicately balanced lever. In turn the lever marked upon a smoked drum, thus recording each drop of secretion. With this equipment he could determine quantitatively the effect of various conditions upon the flow of the secretions. In certain animals he also cut the esophagus and arranged it in such a way that, when the dog swallowed, the food dropped into a pan instead of entering the stomach. Under these conditions the dog would eat indefinitely and the secretions continued to flow. Pawlow also measured the flow from the salivary glands when the animal was being stimulated by the sight and odor of food.

As early as 1878, Richet observed a girl whose esophagus

[1] Cannon, W. B., *Bodily Changes in Pain, Hunger, Fear, and Rage.* New York: Appleton, 1915.

[2] Pawlow, I. P., *Conditioned Reflexes, An Investigation of the Physiological Activities of the Cerebral Cortex.* Oxford Uni. Press, 1928. (Tr. Anrep.)

had closed. She was obliged to 'eat' through a gastric tube after she had chewed her food. Whenever she was masticating a favorite substance gastric juices flowed in abundance before the food was deposited in her stomach. In 1904, Hornborg studied a similar case of a boy whose esophagus was closed, and noticed the same phenomenon, *but when the boy chewed on indifferent substances like gutta percha no secretion followed.*[3] These observations show the importance of pleasurable feelings during the eating of food and indicate the value of pleasant and aesthetic appointments about the dining table, especially for people of fickle appetites. Pleasurable feelings aid in preparing the digestive tract for the reception and digestion of food by stimulating the digestive glands.

Moreover, the nerves that function in the control of these secretions are known. There is, first, the vagus, leading out from the base of the brain to the digestive tract and to other structures within the body cavity. It can be demonstrated that this nerve innervates the glands and muscles of the stomach and intestines. When it is severed before the animal takes food, stomach contractions and gastric secretions do not occur. When the nerve is cut after the animal has begun to eat, the contractions and secretions which have already commenced do not cease. Innervating nerves also connect the base of the brain with the salivary glands. Both sets of nerves make contacts with others from the eye and nose, thus providing a mechanism which sets off the secretions when food is sighted or smelled. From all this the evidence is fairly conclusive that the pleasurable emotive behavior associated with eating involves action of the digestive glands.

(2) The Effects of Unpleasantness and Excitement on Digestion. Vexation, worry, fear, anger and anxiety are unfavorable to digestion. Cannon tells of a woman who was taken to the hospital with acute indigestion. An examination in the morning showed that her dinner of the evening before was still in her stomach. On being questioned she related the story of a quarrel with her husband that evening when he had returned home drunk. The evident cause for her indigestion is revealed by experiments on animals. Bickle and Sasaki

[3] Quoted by Cannon, *op. cit.*

found that in dogs gastric juice was secreted for 15 to 30 minutes after a pleasurable five-minute feeding period during which time 66.7 cc. of pure gastric juice were produced. But when a cat was shown to the dog just before the latter was fed, the dog became greatly excited and during the five-minute eating period no secretions came; even in twenty minutes only 9 cc. had appeared.

Not only is gastric secretion inhibited by excitement, but the digestive contractions (peristalsis) of the stomach and intestines are checked. These facts were demonstrated by Cannon who allowed a female cat with kittens to eat and partly digest her meal undisturbed, then he took her kittens away. As a consequence, peristalsis stopped and commenced again only after the cat had been petted and had begun to purr.

Before emotive behavior was studied experimentally the effect of fear upon salivary secretions had been recognized. Lecturers had noticed that while speaking in public their mouths became dry. Under these circumstances the frequent demand for water was caused not so much by strain on the throat as by a dryness resulting from worry and excitement. Long ago in India when several members of a community were suspected of a crime they were submitted to the 'ordeal of rice.' Consecrated rice was given them to chew after which they were required to spit it out upon the leaf of the sacred fig tree. If any one ejected his rice dry it was taken as proof that fear of being discovered either by man or by the gods had dried his mouth. Accordingly he was judged guilty! It is clear from these general observations that fear, pain and excitement involve an inhibition of salivary secretions.

(3) The Adrenal Gland in Its Relation to Emotive Behavior. Evidence of further organic changes in emotive behavior is derived from a study of the *adrenal glands.* The adrenal or supra-renal glands, of which there are two, lie close to the kidneys. They consist of two parts, the *cortex,* the functioning of which is little understood, and the *medulla,* which is composed of nerve-like tissue. If both adrenals are removed in animals death follows in a few days, after a gradual decrease in body temperature and in blood pressure

together with an onset of muscular weakness and general emaciation. In human beings there is a malady known as *Addison's disease* that is characterized by a degeneration of the adrenals. Patients suffering from this disease *show very little emotion,* lose their muscular tone, develop general debility and emaciation, exhibit feeble heart action, lose appetite and take on a peculiar bronze complexion.

Evidently the adrenals are involved in emotive behavior. It remained for Cannon and others to reveal the facts. The procedures they undertook in ascertaining the exact rôle played by these glands in the life economy of the organism constitute an interesting chapter in physiological psychology and are good examples of functional analysis. It was thought that the adrenals poured directly into the blood stream a secretion the presence of which affected other organs. In order to test this hypothesis the *first* step was to procure some blood from the inferior *vena cava,* a large vein *near the glands,* and to determine how this blood affected intestinal (smooth) muscle which will contract rhythmically although detached from its nerve supply. It turned out that blood thus obtained from an unexcited animal had no effect, but that *excited blood containing as small an amount of adrenalin as one part in twenty million stopped the contractions.* To check these results pieces of muscle were placed in blood from the kidney vein of an excited animal, a vein that is farther away from the adrenals than the *vena cava.* No relaxation took place, the presumption being that the adrenalin liberated during excitement had not reached more remote points of the circulatory system.

The *second* step was to remove the adrenal glands from a number of animals and to examine their blood after they had been excited. This blood failed to inhibit the contraction of smooth muscle. To verify the result, 'excited' blood was treated with oxygen to destroy the adrenalin, under which condition it had no effect on the muscle. *Third,* the sciatic nerve (in part a pain nerve) of a cat under anaesthesia was stimulated electrically from three to six minutes. Blood taken from this animal did inhibit smooth muscle contractions. Evidently, therefore, stimulation of the sciatic nerve con-

ditioned a discharge of adrenalin into the blood of the animal although the animal was under an anaesthetic. *Fourth,* the nerve supply of one adrenal was severed in a cat and the other nerve kept intact; then the cat was frightened. The unmolested gland was considerably depleted of its contents while the other showed very little effect from the exciting stimulation. *Fifth,* both adrenals were disconnected from their nerve supply and the animal excited. Blood from these animals exerted no effect upon smooth muscle.

Thus it seemed apparent that during exciting emotion and pain the adrenals discharged excessive amounts of their secretion into the blood stream and that this secretion caused contractions to cease along the digestive tract. By careful chemical methods the effects of different amounts of this secretion on smooth muscle were measured. One part in a million stopped the contractions completely; one in two million almost stopped them; one in three million considerably lowered the tonus of the muscle and made the contractions longer as well as more sluggish.

(4) The Discharge of Glycogen from the Liver. With methods similar to those just described it was found that during emotional excitement adrenalin induced the liver to discharge excessive amounts of its *glycogen* into the blood stream. Glycogen is an animal starch made in the liver and freed by it into the blood in the form of sugar. This sugar is easily absorbed by the external or skeletal muscles of the body where it is converted into motion and heat. Well supplied with this substance muscles contract with greater vigor.

Experiments showed that injections of adrenalin into tired animals refreshed them evidently through its effect upon the glycogen output of the liver. They showed further that, during excitement, if too much glycogen was liberated into the blood it seeped through the kidneys and could be detected in the urine (*glycosuria or diabetes*). Cannon discovered signs of glycosuria in four out of nine Harvard medical students after a hard quiz, while only one out of nine showed these symptoms after an easy examination. Half of the Harvard football squad had it after an exciting game although five of the number tested had not played. Experimenting on

cats, Cannon found sugar in the urine within a half hour after subjecting them to prolonged excitement. In another experiment he removed the adrenals and found no trace of glycosuria after the cats had been excited for two and three times the period sufficient to produce symptoms in unoperated animals. It had long been known that grief, anger and fright seriously aggravated a person suffering from diabetes and many cases had been reported of the onset of this disease following emotional shock. Also it had been noticed that fear psychoses in insane patients were often attended by diabetes. These facts could now be definitely understood, for diabetes is caused among other things by a prolonged over-excitement which fills the bloodstream with excess sugar.

(5) The Association of Adrenalin with Blood Coagulation. Adrenalin hastens the coagulation time of human and animal blood either during periods of excitement or after the artificial injection of adrenalin into the blood stream. Cannon found that the average coagulation time of blood, fresh from the artery of an excited cat, was 5.7 minutes during the first twenty minutes. During the next hour the time had dropped to an average of 2.6 minutes. When the adrenals were absent exciting the animal did not hasten the coagulation. In these particular experiments the investigator had to exercise great care in order to keep his conditions adequately controlled, for other factors than the presence of adrenalin have an influence upon the coagulation of blood, as for example, temperature and the presence of foreign objects. In fact numerous efforts in these earlier experiments failed to locate the exact means by which the faster coagulation was produced. Apparently, the effect was not caused by the direct action of adrenalin on the blood as might have been expected, because the blood must circulate through the abdominal viscera before the effect is noticed, and the exclusion of the liver from the uncontrolled conditions lengthened the coagulation time. Evidence seemed conclusive, however, that in emotionalized animals and in animals suffering pain the coagulation time of the blood was shortened.

Still other effects in animals were noticed when adrenalin was injected into their blood. The smooth muscles of the

bronchioles of the lungs were relaxed; the blood was driven from the abdominal viscera to the dilated arteries of the external muscles and brain; blood pressure was increased.

(6) Other Glands. Many important contributions to our knowledge of emotive behavior have come also from a study of other ductless glands. Especially is this true of the thyroid apparatus in the neck. A lessened emotional response is associated with an insufficiency of thyroid secretion and an exaggeration of emotions attends an excess of the secretion. The pituitary apparatus at the base of the brain, and ductless sex glands both in the male and female, also have much to do with various types of emotional response.

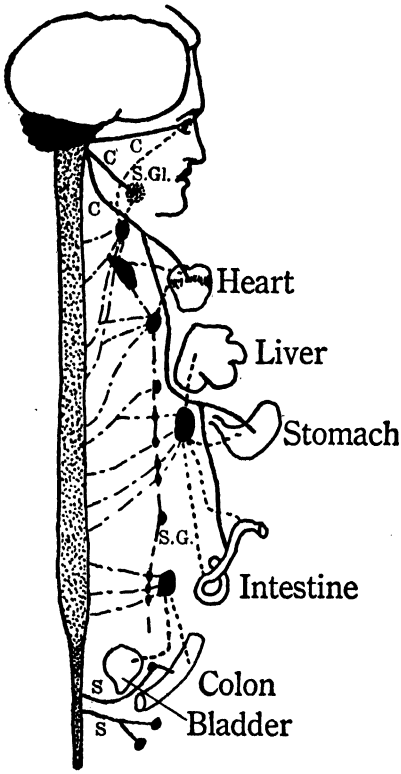


FIG. 16. DIAGRAM OF THE AUTONOMIC NERVOUS SYSTEM (greatly simplified).

C, C, C, fibers of the cranial division leading out from the medulla. *S, S,* sacral fibers to the organs of elimination. Dashed and dotted lines are sympathetic fibers. *S. Gl,* salivary glands; *S. G.,* spinal ganglion (one of a chain of ganglia).

The Functioning of the Autonomic Nervous System in Emotive Behavior. The foregoing evidence of organic changes during emotive behavior is not complete. It remains for us to discuss the *autonomic nervous system* which controls these numerous changes when the animal or human being is undergoing pleasurable experiences and when he is suffering excitement and pain. This system is composed of three divisions, the *cranial, sympathetic* and *sacral,* the first and third of which are called the *parasympathetic* system. (Figure 16.)

The Sympathetic Division. The *sympathetic division* consists of (1) a series of ganglia (centers of co-ordination of nerve inpulses) along each side of the vertebral column, (2) various plexi (singular, plexus) of similar function distributed over various parts of the body, (3) nerve fibers leading from the spinal cord to the ganglia, (4) nerve fibers connecting the ganglia with one another and with the plexi and (5) fibers from the plexi to various organs and structures of the body. This system is largely if not altogether *motor* in character; it conducts nerve impulses to the organs of the body but supposedly not to any great extent *from* them to the ganglia and spinal cord. Its control over the bodily organs is of a 'reflex' character, not under voluntary control, and varies for different organs.

The functions of this system are numerous and varied. It contracts the radiating muscles of the iris, dilating the pupil; it accelerates heart action; relaxes the lower colon; contracts the muscles at the exit of the bladder; innervates the adrenal glands and excites both the external and internal musculature of the reproductive organs. It inhibits the muscles of the stomach and intestines; excites the liver; contracts tissues around the base of the hairs; contracts the surface arteries and sweat glands; inhibits the salivary glands; innervates the tear glands and contracts small muscles behind the eyeballs, causing the eyes to bulge. It also dilates the nostrils and increases the action of the chest muscles in breathing. A formidable array of consequences! And most of these changes take place during intense emotional excitement and pain!

The Cranial Division of the Autonomic Nervous System. Leading out from the base of the brain are nerve fibers which constitute the *cranial division* of the autonomic system. Certain of these fibers (in the third cranial nerve) pass to the constrictor muscles of the iris. Action of these fibers constricts the pupil. Other fibers (in the seventh and ninth cranial nerves) go to the salivary glands where they have an innervating effect. The main part of the cranial system, however, is composed of the vagus nerve (the 10th cranial, see page 451). This nerve slows heart action, inner-

vates the glands and muscles of the digestive tract as far down as the lower colon and perhaps provides nerve mechanisms for the sense of hunger. The cranial division is partly *sensory* because it conducts from sense organs in the linings of the digestive tract toward the central nervous system.

The activities which this system controls have to do with the intake and conservation of energy of the body; the system prepares the digestive tract for food by setting up and maintaining a flow of digestive secretions; it keeps food passing along the alimentary tract. In controlling the size of the pupil it shields the delicate internal mechanisms of the eye from intense light; it conserves the cardiac muscle by giving it longer periods of rest between contractions; finally, it maintains the muscular tonus essential for the proper contractions of the alimentary tract. These functions all result in *preserving* the energies of the organism.

The Sacral Division of the Autonomic System. Certain nerves (second, third and fourth sacral) lead out from the lower spinal cord to organs of the abdominal region. These nerves contract the walls of the colon; relax the sphincter muscles of the anus; relax the muscles at the exit of the bladder and exert an inhibiting effect upon the arteries and tissues of the reproductive organs, keeping them relaxed. In general this part of the system controls the evacuation of waste matter from the body and provides mechanisms for sensing the need of defection, and voiding of urine. This, as well as the cranial division, is both motor and sensory.

Relation of the Sympathetic to the Cranial and Sacral Divisions. It is an interesting fact that two of these systems, the cranial and sacral, send fibers to the same structures of the body as are supplied by the sympathetic nerves, but their influence on these organs in each case is the opposite. The sympathetic, during excitement and pain, preempts the use of certain of these organs and causes others to cease functioning. *In short, it controls the output of that energy which accumulates under the influence of the parasympathetic system.* The sympathetic system, in other words, is an important factor in the redistribution of body energy during emotional excitement. This redistribution leads to profound consequences

Practical Consequences of these Widespread Organic Changes. Whatever may have been the cause of this elaborate array of functions of the autonomic nervous system, its practical utility for the organism is obvious.

First, the digestive glands and muscles cease functioning during excitement and pain; blood which ordinarily collects in large quantities about the digestive tract while digestion is going on shifts to the external muscles where its energy is *available for use in heightened muscular activity.*

Second, the liberation of stored animal starch from the liver into the blood stream gives still more available energy to the external muscles.

Third, increased blood pressure and heart action produce a more rapid circulation of blood through the organism, thus a more rapid washing from the muscles of those toxic substances that are given off during increased activity.

Fourth, increased breathing and relaxation of the bronchioles means a more rapid absorption of oxygen and elimination of carbon dioxide.

Fifth, the greater coagulability of the blood happens to protect the organism from excessive bleeding in case of injury. It is significant that pain and emotional excitement should be associated with this phenomenon of coagulation, for the times when the organism is excited or suffering pain are the times when the chances of injury are greatest.

Sixth, during heightened muscular activity the temperature of the body rises. Intense emotive behavior involves greatly increased muscular action; meanwhile the sympathetic system excites the sweat glands and causes the organism to perspire. The effect of this is to prevent fever by reducing the temperature of the body.

To summarize, in emotive behavior there is an elaborate internal organic change upon which there is superimposed a vastly increased activity of the central nervous system and of the external muscles of the body. All this happens in hurriedly seeking shelter from impending danger, in engaging in combat with a rival, and in fighting when cornered. Whatever the

response, it is a complex performance in which all the organism's resources are being used in vigorous action with respect to a definite end. The distribution of the organism's energies is partly under the control of the autonomic system, and as a consequence the organism is prepared to defend itself in a crisis. To reason, however, that these elaborate 'preparations' exist in the economy of the organism's life *merely because of their utility* fails to explain them. Nevertheless, this view has been popular. The effort to bring emotive behavior under the general laws of least action and configuration is a preferable alternative.

Emotive Behavior and the Law of Least Action. It is certainly a more difficult and a less direct procedure for an animal to lie down and die in the face of a crisis than to defend itself. Yet flight and combat are not to be explained in terms of an instinct for self-preservation (see page 169). It is known that every unified pattern or system of physical forces can be disintegrated only by the application of force; the system opposes disturbing forces from without. For example, a falling body is part of a dynamic physical system and can be changed in its course or stopped only by the employment of energy. It is no more striking in principle that a living organism should resist destruction, since it is a complicated organization of forces. The organism's defense reactions which have constituted the subject matter of the foregoing chapters are precisely those expenditures of energy that any outside force must overcome in order to disturb the balance of the organism and to destroy its unity. In turn the organism, like any physical system, undergoes disintegration in proportion to the energy it expends in resisting outside disturbances. There is one striking difference, however, between the living organism and the gravitation system in which an object falls. *The organism possesses 'stored energy'* [4] *in its muscles and nervous system, which it releases with an expenditure of force all out of proportion to the energy of the exciting stimulus; the organism resists disturbing influences with a vigor that is proportional to its stored energy. This stored*

[4] Meaning unstable forms of energy; energy freely released and expended.

energy is not accumulated for future needs; it is necessary in the present and at all times for maintenance of organization within the system.

A physical system of great complexity and specialization like the animal or human being is an organized unit *by virtue of this relatively free energy.* Witness the fact that within the organism this energy is constantly shifting and being transformed; the organism is constantly expending it and acquiring more from oxygen and food, all in the process of maintaining its own organization. We may, therefore, suggest a corollary to the principles associated with least action, namely, that the *greater the complexity and specialization of an energy system, the more energy is required to maintain the unity of that system.* If this corollary is true it would follow that relatively less energy from without the complex system is required to destroy that system and relatively more energy within the system itself is expended in meeting the disintegrating forces that act upon that system from without. The living organism is one of these complex systems.

We have interpreted the efforts of an organism to defend itself in danger, just as we explain the weight of an object, namely, in terms of fundamental laws. It is not necessary to regard emotive behavior as the response to a need. The discharge of energy in the fighting and fleeing organism is an inevitable resistance to forces which are disturbing its unity. If the response is configurational, and if it is the resolution of a tension, it may be supposed that it occurs in the line of least action. That is, the organism takes the most direct route in time toward a goal. Interpreted more freely, the movements are so co-ordinated that the organism reaches a goal or relieves a tension in the simplest and most direct way under the circumstances, considering the organism and the external stimuli to which it is reacting as a total energy system. Emotive behavior, then, becomes a special case of 'action and reaction.' In the reaction of the organism, being 'aware' of danger, feeling the need of self-protection, and intending to escape, are part of the energy expended.

A Return to the Problem of Instinctive Behavior. A study of the organic responses during emotion clearly shows

to what extent behavior is conditioned by organic structure. A complicated autonomic system is found within the organism, ready to function at any time after maturation. Likewise, there is a complete group of external muscles also ready to function partly under the control of the autonomic system.

An old and familiar problem can now be revived. Is it possible to account for 'instinctive' behavior in terms of organic structure? The answer to this question is furnished by the detailed knowledge accumulated in this chapter relative to the organic phenomena of emotion. *First,* as to the alleged instinct or urge to eat. The organism sees and smells food, using specialized sense organs in the eye and nose; psychic secretions commence, preparing the digestive tract for food. The organism's stomach is empty, a condition which leads to painful contractions felt as hunger. This intra-organic stimulation produces bodily tensions which, according to the circumstances of least action, demand termination. Securing the food is a form which these tensions assume. It is also a goal-activity; figuring in the total situation is the food-object as a goal, giving direction to the organism's movements (cf. page 125). When the stomach is full the stimulation ceases and the tensions subside. Hence harking back to an inherited tendency is redundant; *growth provides the specialized organs that function in the manner described.*

Second, as to sex behavior, in the young child this behavior is aroused by stimulation of the so-called *erogenous* zones, the surface of the sex organs, ventral surface of the abdomen near the sex organs, and the lips and the breasts. At birth the neuromuscular structures responsible for sex behavior begin gradually to mature, making possible a certain amount of interest in the sex organs at an early age. Stimulation of the erogenous zones causes tensions to arise relief from which is obtained in the course of manipulating the organs. As the organism matures not only stimulation of the erogenous zones sets up these tensions but also the sight of a sex object. As the glands of the reproductive organs develop and more intra-organic stimulation is afforded, these tensions are resolved only when the exciting stimulus is removed or when the reproductive act is completed with reference to the sex object as a

goal. The outstanding condition of all this behavior is the sympathetic nervous system and its connected glands.

Third, as to care of the young, in its beginnings care of the offspring by the mother is in part a function of her organic condition, for example, the condition of the breasts which furnish intra-organic stimulation. More particularly, once an offspring functions as a goal and conditions remain undisturbed, it continues to function in this manner through an acquired insight into the total situation in which the offspring figures. That is to say, the parent grows to the problem of caring for the child as the child develops. And finally, care of offspring is maintained by social pressure not only from within the family group but from larger groups as well.

But what about the fluttering of the quail, the savage attacks of the lioness and the frantic efforts of a mother to save her infant from the flames? These activities anywhere are certainly not blind and mechanical as the concept of instinct would make them; they are modes of intelligent behavior conditioned first, by a nervous system sufficiently evolved to permit a response to objects in their relationships and second, by the blocking of a goal-activity. Just as the animal resists disintegrating forces it resists being thwarted in a goal-activity. Anything which comes between the organism and its goal produces a tension; it is a counter stimulus. The fighting of a parent for its offspring is not different in principle from the effort to overcome an obstacle in the way of securing food. The obstacle is responded-to in its relation to the food-goal by climbing over it, going around it, or removing it. An obstacle in the way of parental behavior is overcome in whatever manner the existing conditions permit.

Fourth, fighting is not 'instinctive.' The organism, like all physical systems, is exhibiting activity in the direction of a goal or remote end the reaching of which completes the establishing of an equilibrium. The tension of the organism and therefore the vigor of its response is accentuated by the action of the autonomic nervous system, the adrenal and perhaps thyroid glands.

Finally, whether or not emotive behavior shall occur at

all depends upon the *degree of maturation* of the organism's structures, especially the glands and nervous system. This maturation of organs determines what situations shall function as goals and limits the extent to which intra-organic stimulation energizes the response toward the goal.

General Conclusions in Regard to Emotive Behavior. (1) Our brief study of the autonomic nervous system and its chain of interrelated glands illustrates again the fundamental principle that it is only the *organism-as-a-whole* that exhibits behavior. Furthermore, it substantiates the older theories insofar as they included bodily reactions among the phenomena associated with emotion. Accordingly, the organic changes which we have been discussing are features of emotive behavior no less than are mental processes which can be abstracted from the unified response. So too, the overt actions of fleeing, fighting and mating, which may be abstracted from the response as a whole, are to be regarded as features of the emotion. We may define emotive behavior, then, as a response of the organism-as-a-whole, the outstanding criterion of which is an intra-organic and muscular stimulation that depends upon the functioning of the autonomic nervous system and its related organs. At the same time, emotive behavior involves insight.

(2) Although intra-organic stimulation and its related mental processes and bodily movements are the prominent characteristics of emotion, they do not constitute a complete picture of the organism's behavior at the time. Emotion is not a response separate from intelligent, social and learning behavior; in any instance it is an abstracted aspect of the organism's total activity. Simultaneously the organism is perceiving a goal and hence its behavior is intelligent; it may be responding to a social situation in which case its behavior is social; and it may also be learning a certain task. Accordingly, an emotive activity is any configurational reaction which resolves itself more quickly and vigorously than other responses because of the greater stress under which it begins.

(3) The supposedly spontaneous and unlearned aspects of emotive response which the instinct hypothesis with its emphasis upon heredity attempted to explain, proved no exception

to the principles of configurational response and least action. In fact they substantiate them further, since in interpreting emotive behavior it was possible to formulate a corollary of these laws relating to the 'stored energy' of the highly complex organism. And as we have seen, the autonomic nervous system is a dominant factor in the control of the accumulation and release of this energy.

(4) Strictly speaking, behavior under excitement is not controlled by emotion; it *is* emotion, and is controlled by goals and intra-organic stimulation. The combined action of these factors induces the most demanding of any tension which arises in the life of the organism. It therefore becomes intelligible how enraged and frightened individuals are capable of greater physical feats than those who are not excited. We all know in a general way the importance of emotion in football, in racing and in the rowing sports. The value of cheering, for instance, is to excite the players. Similarly the remarkable endurance of savage dancers who work themselves into a frenzy of religious zeal is to be attributed in part to the stimulation of the sympathetic nervous system and to the action of the adrenal glands. The story is told of a battle between the British and a Malay tribe in which the Malays were almost insane with zealous rage accumulated during a preliminary religious ceremony. Although in many cases they had been literally riddled with bullets, they charged the British soldiers with hand weapons ready, and not until they had reached their enemy and had delivered the intended blow did they collapse.

We can also understand the value of substitutes for the fighting emotions such as competitive sports, and the need for compensating activities as an outlet for the worried, depressed or highly sexed individuals. The emotional individual must be active physically or the increased toxic products from heightened metabolism are not properly eliminated. If the emotive responses are not permitted to run their natural course or to terminate in a substitute activity, it means that they never end. The individual is forever striving, without satisfaction and therefore without rest, to reach the goal to which his emotional behavior is directed. He is con-

stantly resisting disintegrating forces. It is no wonder that such a person, after a prolonged period of unsuccessful emotional conflict, attempts to maintain the unity of his personality by constructing an imaginary goal which he can reach, although it is accomplished by going insane.

Mechanical Methods of Studying Emotive Behavior

The Psychogalvanic Reflex. We turn next to an entirely different line of research, not so successful in revealing conditions of emotive behavior, but nevertheless of considerable importance. It is the measurement of the so-called expressive movements of emotion.

In 1888, Féré and Tarchanoff [5] discovered that when two electrodes of a delicate galvanometer (instrument for measuring or detecting weak electric currents) were applied to the skin, any emotional and muscular activity, induced at the time, caused certain electric currents or changes in potential. These currents, known as galvanic effects, could be measured roughly by the deflections of a galvanometer string or mirror. Since then the literature bearing on this method has grown exceedingly voluminous, but with little progress in the interpretation of results. During emotional activity there is evidently a decrease of resistance to the current as it passes between the electrodes on the subject and hence through the galvanometer. Whatever takes place may perhaps be described as a *depolarization effect,* a shift in potential between the negative and positive electrodes. However, it may be that a current generated by the body and sent through the skin tends to be counteracted by the current from the external source. Such a lessening of the inner force would increase the deflection of the galvanometer. We are still in doubt, however, as to the physiological cause of the depolarization. Sidis and Nelson, experimenting on animals, used electrodes which penetrated through the skin and still obtained results. They therefore concluded that the deflection was of muscular

[5] *C. R. Soc. de Bio.,* 1888, 217. Cf. Ladd and Woodworth, *Elements of Physiological Psychology,* 509; also Landis, C., and DeWick, H. N., "The Electrical Phenomena of the Skin." *Psy. Bull.,* 1929, Vol. 26, 64–119.

origin. Later, Waller found evidence against this view. Authorities are divided on the question whether secretions from sweat glands are the cause.

The psychogalvanic reflex can be easily demonstrated before a class. Let a subject sit relaxed with each hand immersed in salt water electrodes attached by wire to a mirror galvanometer through a Wheatstone bridge. The bridge is introduced to control the current. A beam of light is directed to the mirror and reflected upon a screen, and the battery current and apparatus adjusted until the spot of light is in the center of the screen. Suddenly frighten the subject, say by clapping two boards behind his back; the mirror will be deflected, the spot will move to one side, perhaps clear off the screen. This shows that there has been a decrease in the resistance the subject's body offers to the current.

The Electrocardiograph. Physiologists have known for a long time that the human body under certain conditions exhibited galvanic effects. As soon as delicate galvanometers were built men found that they could produce slight deflections by merely touching the leads. In other words the human body itself acted as a battery. These effects were particularly apparent during muscular activity, although only recently it has been found that there are probably electrical concomitants of all protoplasmic activity. When nerves or muscles are stimulated strongly, appreciable currents arise that can be recorded. Recently a method had been devised by which these action-currents, of whatever nature they may be, may be recorded for the human heart. Such a record is called an electrocardiogram.

At first one might suppose that it was necessary to open up the thorax and lead wires directly from the heart. And this is exactly what has been done in experimental work with the dog. Two electrodes are placed directly on different portions of the dog's heart. The impulses are amplified and transformed into movements of a light beam which are in turn recorded on a moving film. Accompanying every beat of the heart there is an impulse which passes from the auricle, the receiving end of the heart, to the ventricle, the end which passes the blood on.

It would hardly be practical to place electrodes directly on the heart of a slightly ailing patient, so these impulses have to be measured indirectly. For this purpose electrodes are attached to the exterior of the body. It is customary with the present standardization of technique, to use the right hand, the left hand and the left foot. Each of these is placed in a container with salt solution and a metal plate. With these three electrodes circuits may be hooked up which pass in three directions through the body past the heart. From records taken in each of these three directions a resultant picture of what takes place can be constructed.

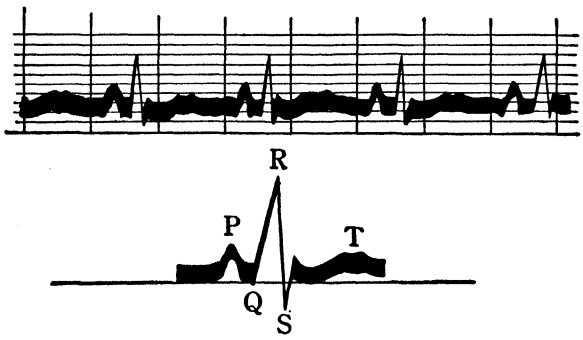


FIG. 17. SAMPLE ELECTROCARDIOGRAPH RECORD OF HEART ACTION (Adapted from Howell).

The letters refer to parts of a single heart beat which have special technical names (see text).

The analysis of the electrocardiograph records is a task only for the highly trained physiologist. He recognizes certain waves, the P wave, as being indicative of the start of the auricular contraction, followed by the QRS complex which comes just as the ventricle is beginning to contract, and a T wave which gradually increases to a peak as the ventricle begins to relax (see Figure 17). It is by carefully studying the variations from this usual wave form that he is able to tell what is abnormal about any particular person's heart beat. There is, for example, a disturbance of the heart in which an extra contraction occurs. In this case the cardiograms will show the time and direction of this extra systole, one phase of the QRS complex being badly out of proportion if the

systole is in the ventricle. In the same way various types of heart block can be recognized and diagnosed. One of these is called delayed conduction and is characterized by an abnormally long P-R interval. Dissociation of auricular and ventricular beats can also be recognized. In fact there is a condition called auricular flutter which can only be diagnosed by this method.

Although the electrocardiogram gives us a fairly complete picture of the heart action, there has been as yet no comprehensive study made with it of heart action in strong emotional situations. This is in part due to the complexity of the records obtained and to the fact that other more simple devices such as the plethysmograph and sphygmograph give records which are sufficient for our present understanding of these bodily processes.

An Experiment with the Electrocardiograph. Using a standard Hindle electrocardiograph with two electrodes, Blatz [6] recorded heart action during and subsequent to the arousal of fear. He sought to answer the following questions: What is the effect of an unexpected fall? Is there any adaptation to this fall if it is repeated with the knowledge of the subject? What adaptation, if any, occurs with subsequent unexpected falls? He excited fear in his subjects by dropping them backwards unexpectedly while they sat in a chair. The first unexpected fall had a marked effect on the pulse as the accompanying figure shows. The second fall (occurring the next day) produced a less disturbance and subsequent falls produced even less. Figure 18 shows the electrical changes that took place in one subject after the first and second falls. (This is not an electrocardiogram, but a curve obtained from it.) During repeated falls, with the subject warned in advance, there were decreases in all effects both in degree and duration. Yet after repetition an unexpected fall produced effects resembling those of the initial stimulus. The electrical changes as recorded by the cardiograph consisted of an increased development of electromotive force appearing one half

[6] Blatz, W. E., "The Cardiac, Respiratory, and Electrical Phenomena Involved in the Emotion of Fear." *J. of Exp. Psy.*, Vol. 8, 1925, 109–132.

second to three seconds following the fall and lasting for a period of one to six minutes.

The Sphygmomanometer and Pneumograph. The *sphygmomanometer* is an instrument used in measuring blood pressure. In one form it consists of a U-tube of glass in which there is a column of mercury. When an air-tight sleeve attached by a rubber tube to the sphygomomanometer tube is wrapped around the subject's arm and filled with air, the air pressure displaces the mercury in the U-tube. The blood in the arm counteracts this air pressure to a certain extent. Thus the position of the mercury in the tube indicates in this round about way the amount of blood pressure in the arm. In another type of sphygmomanometer a pressure gauge with a graduated dial and pointer is substituted for the column of mercury.

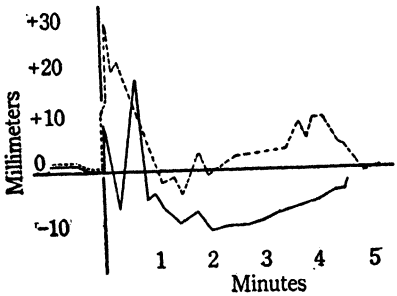


FIG. 18. CURVE OF ELECTRICAL CHANGES TAKING PLACE DURING EMOTION (Blatz).

The dashed line shows the extent of electrical changes in one subject following an initial fright. The solid line shows the changes that occurred during a second fright induced under conditions similar to the first. Distance of these curves from the O-line represents extent of positive or negative variation in electrical potential in the body of the subject.

There are various kinds of *pneumographs* a common form (Sumner) of which consists of a long spiral spring covered by a rubber tube. One end of the tube is closed and the other end is attached to a rubber tube which leads to a recording device known as a *tambour*. The tambour is a simple pan-shaped instrument usually of metal across the top of which is stretched a thin rubber diaphragm. Very slight changes in air pressure within the tambour cause the diaphragm to rise and fall. It is a simple matter to adjust a writing lever so that these fluctuations of the diaphragm can be recorded on smoked paper wound around a rotating drum. The pneumograph is fastened tightly about the chest or abdomen of the subject. When he inspires the pneumograph stretches and sucks in air from the tambour. When he expires the pneumograph contracts and forces air into the tambour.

As a typical study of emotive behavior with the use of these instruments we may select a recent investigation by Landis and Gullette.[7] Their object was to ascertain first, what uniformities there were in changes of blood pressure during various emotional experiences and second, the ratio of inspiration to expiration. Records were obtained from 25 subjects in situations like the following:

1. Jazz records played on the phonograph.
2. Reading a passage from the Bible.
3. A firecracker exploded under the observer.
4. Observer asked to write down embarrassing event which was then read aloud.
5. Looking at nude art pictures (female).
6. Placing hand in bucket of live frogs; at the same time getting electric shock.
7. Observer asked to decapitate a live rat; if he failed, watched experimenter do it.

While the results of this study definitely revealed the limitations of the method, certain interesting facts came to light. In only two of these situations, those which involved surprise, were there uniform characteristic changes in blood pressure. In these cases there was a sharp rise followed by an immediate fall. In the 'shot' situation there took place the largest fast change of any during the experiment, a jump from 134 mm. to 154 mm. pressure in 20 seconds. On the average, blood pressure increased 4.2 mm. Uniform disturbances in breathing were rare.

The ratio of inspiration to expiration (time of inspiration divided by time of expiration) was higher during falsehood than while telling the truth. Many attempts had been made previously and many have been made since to find a definite relationship between breathing phenomena and lying. Results are not sufficiently uniform to justify their use in detecting liars, but telling a falsehood in many instances seems to be in part an emotional activity that is measurable to some extent by means of the pneumograph.

[7] Landis and Gullette, "Studies of Emotional Reactions III. Systolic Blood Pressure and Inspiration-Expiration Ratios." *J. of Comp. Psy.*, Vol. 5, 1925, 221–253.

The Plethysmograph. The *plethysmograph* is an instrument employed in recording and measuring changes in blood volume. The Lehman model is perhaps the most used. It consists of a metal cylinder into which the subject's arm is inserted within a rubber mitten to make the device water tight. With the arm in place the remaining space in the cylinder is then filled with water to a level visible in a glass chimney which is fastened to the upper surface of the cylinder. The water level in the chimney rises and falls with each heart beat of the subject and also with the migration of blood to and from the arm. By means of a rubber tube and tambour, corresponding air displacements are picked up to be recorded at the other end of the tube by a writing-lever. Other varieties of plethysmographs have been constructed for the hand, a single finger, and the foot.

Plethysmographic studies yielding reliable results in connection with emotion have not yet been made. The apparatus is too difficult to manage, friction absorbs too great a portion of the displacements to be recorded, and movements of the subject's arm within the cylinder are hard to control. However, a technique devised by Ford [8] and used later by Lindley [9] removes many of the drawbacks of the older procedures. Ford converted an interrupted current into the proper voltage to burn with its sparks a series of holes through a moving sheet of paper. He directed this current through a pointer poised just above the paper. The pointer actuated by changes in the plethysmograph and tambour now lost none of its motion by scraping across the paper. This method had the additional advantage of making possible a record of indefinite length, for with almost any kind of a smoked drum apparatus a long record can not be obtained.

Figure 19 shows a typical record obtained by Lindley. T is a time record in half-seconds obtained by means of a pendulum. H is the heart record and B is the breathing record. S shows when an associate in the laboratory, whose presence was unknown to the observer, shouted suddenly in the latter's

[8] Ford, A. Albert, "Recording Apparatus: The Electro-kymograph." *J. Exp. Psy.*, Vol. 7, 1924, 157–163.

[9] Lindley, S. B., "An Electro-kymograph used in Recording Vasomotor Changes." *J. Exp. Psy.*, 1928, Vol. 11, 325–328.

ear. The effect of surprise both on the heart and on breathing shows in the record. Lindley also found that there was increased blood volume in the arm during prolonged work such as rapidly tracing a maze over and over again or holding the muscles of the body tense for a prolonged period. During relaxation and quiescence the volume decreased.

The Ergograph. The *ergograph* is another instrument sometimes employed in experimenting upon emotive behavior by the method of expression. It is designed primarily for use

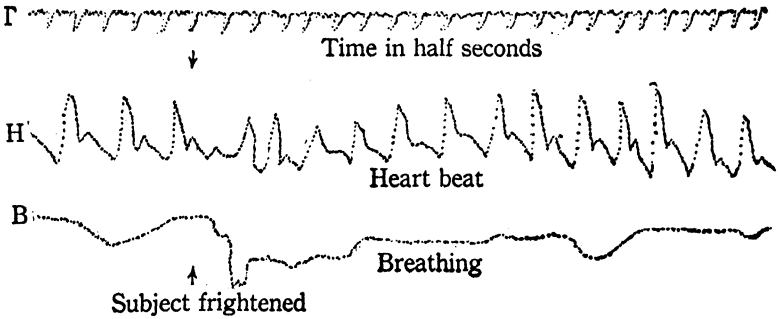


FIG. 19. ELECTRO-KYMOGRAPH RECORD OF HEART ACTION AND BREATHING (Lindley).

After the method of Ford. Notice the irregularity of breathing after the subject was frightened by a loud shout from behind. The heart record is irregular immediately following the stimulus, probably caused by a movement of the apparatus. Note, however, that a few seconds following the stimulus the pulse is stronger (amplitude of record higher) and faster. Many organic phenomena of emotion characteristically appear about five seconds after the exciting stimulus.

in obtaining 'fatigue curves' of muscular contraction. The subject's arm is harnessed tightly into a cast-like holder which also confines the second and fourth fingers. The middle finger is then fastened to a pulley that carries a weight. As the subject lifts the weight a pointer attached to a carriage on the pulley moves back and forth and records the contractions on a revolving smoked drum. If the proper weight is selected the finger begins to 'tire' after a few contractions and shortly gives out altogether. The fatigue, however, is in the nervous system more than in the muscle. The speed of the contractions is controlled by instructing the subject to pull synchronously with the beating of a metronome. With this method it is possible roughly to measure the dynamogenic

or energizing effect of emotional stimuli. Figure 20 shows how a subject begins to contract more vigorously, even after the onset of fatigue, when a martial tune is played to him on the phonograph.

The Automatograph. The *automatograph* may be used in recording movements under emotional excitement, although it was constructed primarily for the purpose of measuring such involuntary arm movements as may occur while the subject is imagining himself doing something with his arm. The Jastrow automatograph consists of a flat glass plate resting upon three steel balls which in turn move upon a glass base.

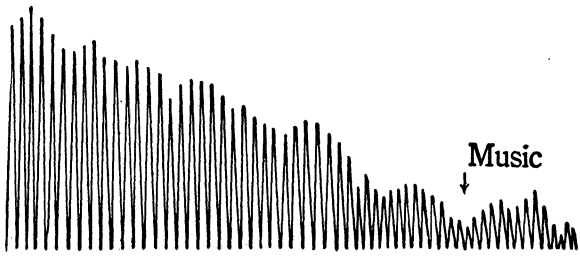


FIG. 20. ERGOGRAPH RECORD OF FINGER CONTRACTIONS.

Each excursion of the marker represents a single finger contraction. The shortening of the excursions indicates the onset of fatigue. Note the slight recovery when music was played to the subject.

To the upper plate is attached a stylus which scratches very lightly across the surface of a smoked piece of paper. The subject is blindfolded and instructed to stand perfectly still with his finger-tips resting lightly upon the upper glass plate. The plate will shift position with the involuntary swaying of the arm, causing the stylus to scratch a record on the smoked paper.

Rate of Metabolism in Its Relation to Emotion. Within the last five or six years several attempts have been made to ascertain whether emotional situations affect the basic metabolic rate (B. M. R.) of the subject as measured by the speed with which he absorbs oxygen through the lungs and gives off carbon dioxide. The subject breathes through and into a 'metabolic machine.' The rate of oxygen consumption is thus measured together with the carbon dioxide given off, the latter

being absorbed by soda-lime. Numerous experiments on the insane seem to yield contradictory results. There is supposed to be an altering of emotional reactions in manic depressive insanity, yet the B. M. R. in patients suffering from acute attacks shows no characteristic disturbance. There is some evidence that unpleasant emotional experiences following suggestion involve a rise in the metabolic rate. On the other hand extreme emotional disturbances in animals involve a decreased metabolic rate. From what we know of the widespread heightening of general activity of the organism during emotive behavior we might be led to expect an increased metabolic rate. Landis [10] sought to throw light upon this problem by measuring the B. M. R. of three subjects while they listened to music and while they were emotionally upset by a strong electric shock. Music did not have an appreciable effect, but the anticipation of a strong electrical shock raised the B. M. R. 6 per cent in one subject, 17 per cent in another and 37 per cent in the third. The emotional disturbance caused by the shock evidently slowed down the metabolic rate slightly in two subjects. The 'normal' B. M. R. in these experiments was controlled as much as possible by the diet of the subjects.

The Conditioned Reflex Method of Studying Emotive Behavior: Discovery of the Conditioned Reflex. While Pawlow was experimenting upon salivary and gastric secretions in dogs he discovered accidentally that the salivary secretion began to flow in one of his animals with no apparent cause. The usual method of inciting the flow was to show the dog a piece of meat, but in this instance there was no meat around. Finally Pawlow discovered that the secretion commenced when he sounded a buzzer that had been used many times as a signal. He came to the conclusion that the dog had 'associated' the sound reflexly with the sight of the meat and that by this association the former had become an adequate stimulus for the salivary response. Controlled experiments soon revealed the correctness of his suspicion. In repeated tests he sounded again and again a tuning fork of a certain pitch, say 256 double vibrations per second, while he

[10] Landis, C., "Studies of Emotional Reactions IV. Metabolic Rate." *Amer. J. of Physiol.*, Vol. 74, 1925, 188–203.

exposed the meat to the animal. Finally he sounded the fork without the meat and still obtained the secretion; but when he varied the pitch of the fork ever so slightly the secretion decreased. It was possible to find a pitch far enough above or below the original stimulus to have no effect upon the saliva. Pawlow called this type of response to a substitute stimulus a *conditioned reflex.*

Here was an excellent method of measuring the sensory acuity of animals. If a conditioned reflex of so precise a character could be set up in one situation it could in another. Would the secretion be conditioned by other substitute stimuli such as visual forms, odors, pressures, and pain? With what nicety could the dog discriminate between these stimuli as evidenced by the appearance of the reflex? Shortly Bechterew, another Russian investigator, discovered that reactions in both striped and smooth muscle could be conditioned. Then it was not long before the conditioned reflex method was being used in all kinds of animal experimentation, even in a study of human behavior. Learning in animals was studied by this technique. If a rat could learn to turn into an alley to the right when one odor was given it and to the left when another was given, it was considered good evidence that the rat could distinguish the odors.

Then the conditioned reflex became a principle sufficient —so its advocates thought—to explain habit formation, the development of emotional responses to new situations, in fact everything! It became a substitute for the law of association as a basic concept in psychology; it led to the development of a new branch of the science, behaviorism, in which every movement and complex of movements of the organism was regarded as a summation of conditioned reflexes.

How the Conditioned Reflex Was Explained. It seemed an easy matter to explain the conditioned reflex, especially the salivary reflex, which is controlled by the cranial division of the autonomic nervous system. Take the case of the tuning fork and the meat. S (Figure 21) represents meat, the adequate stimulus for the flow of saliva. R represents the flow of saliva. At the same time S is given, the tun-

ing fork, S′, is sounded. The dog is inclined to respond also to S′ but the nerve pathway from S to R controls the dog's behavior at that time. The response, R, is draining more energy over nerve routes from S than the feeble response R′ is drawing from S′. But the routes S–R and S′–R′ are not absolutely separate; there are side routes connecting them. Any energy set off by S′ tends to escape over the route being used most at that time; it is drained a little, so to speak, from S′ to R. The next time the act is repeated there is more drainage until finally the route S′ to R is opened through greater use than of the route S′–R′. Then S′ becomes a substitute stimulus for R after S′–R is opened and will arouse R even when the adequate stimulus S is not present.

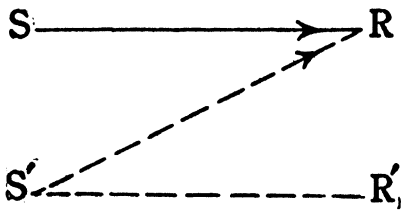


FIG. 21. DIAGRAM USED TO EXPLAIN THE SUBSTITUTION OF STIMULI IN CONDITIONED REFLEXES.

How Emotive Behavior Was Regarded as a Conditioned Reflex. Children seem not to inherit fear of the dark for some of them are afraid to retire with the light out and some are not. This state of affairs, it was thought, might easily be explained in terms of the conditioned reflex. A child is frightened by an innocent prank of the parent just as the light is turned out. The adequate stimulus which aroused the fear was not the sudden onset of darkness, for the latter corresponds to S′. But it came at the same time as the other stimulus S. Since the human nervous system is apparently more plastic than an animal's one repetition might establish a conditioned reflex. Thereafter the child is afraid of the dark because darkness becomes a permanent substitute stimulus.

It was thought that the conditioned reflex might explain the development of emotional complexes. A certain lad will have nothing to do with schools and teachers. Some time previously a teacher rebuked him before the class and greatly injured his pride. Everything about the school room immediately becomes a substitute stimulus. As he looks at the

building upon approaching it the next day his distress flares up again. The building becomes another substitute stimulus and thereafter suggests the emotional reaction. Presently he dislikes to ride by the building and the word, school, becomes a substitute stimulus. Indeed, the possible substitutions of stimuli are practically infinite in number. Watson and Rayner [11] claim by experiment to have verified this view of emotion. They found that an infant, approximately a year old, developed fear of a white rat after he had been frightened several times by a loud sound during the presentation of the animal. Subsequently he showed fear of a rabbit, dog, cotton wool and a hairy muff.

Criticism of the Conditioned Reflex Theory of Emotion. In the author's opinion, however, such a conditioned fear should not be regarded as a *conditioned reflex.* It is more reasonable to apply the configurational hypothesis to the situation and suppose that the child perceived the loud sound finally in *relation to the rat.* That is, the rat came to *mean* something to be afraid of because it must have had something to do with the sound. The rat was always there when the loud sound was presented! So too, objects resembling the rat were also related to the sound. We do not know how explicitly the infant perceived these relationships. Presumably there was no complex thinking just as there was probably no complex thinking in case of the apes in Köhler's experiment. The infant's behavior was similar to that of the Eskimo who carried a ham-bone on every seal hunt after he had once been successful in killing a seal at the time he had the ham-bone with him. Because of the infant's immaturity his perceptual configuration developed more slowly than the Eskimo's.

Other reactions such as comprehending words in new situations for the first time are of the same general character. All of these reactions are conditioned, but merely to regard them as conditioned reflexes or conditioned responses neither explains them nor suggests an adequate explanation, because *the acquisition of new responses involves the perceiving of objects in their relationships, or in other words the construction*

[11] Watson, J. B., and Rayner, R., "Conditioned Emotional Reactions." *J. of Exper. Psy.,* Vol. 3, 1920, 1–14.

of new perceptual configurations! Moreover the conditioned reflex theory presupposes that the whole is only a summation of its parts! Further evidence against the conditioned reflex as an explanatory principle is found in the extremely unstable character of these responses. Even in animals they are built up with difficulty and very shortly disappear if repetitions with the original adequate stimulus are not continued.

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CHAPTER IX

LEARNING: GROSSER FACTS AND METHODS

The Goal and Insight in Their Relation to Learning

Introduction. We began our study of human beings in their natural everyday environment and found that the most obvious and outstanding conditions of their behavior are social. After discussing these conditions in some detail we considered behavior in the light of its more limited and special conditions which, although still more or less social, revealed such characteristics of human nature as might be called intelligent and emotive. Throughout we have followed the policy of going from the more general to the more specialized modes of response and this procedure has introduced us gradually not only to more and more refined methods but to more and more precise facts.

In this and the following chapters we shall continue the same policy. We have already reached modes of behavior sufficiently simple and limited as to conditions to permit laboratory methods of study, more definite means of control, more exact measurement and therefore more certain predictions. Before we conclude this section of the text we shall have narrowed down the conditions of behavior to such an extent and shall, therefore, have abstracted from behavior reactions of so limited a character, that we shall seem to have left our organism-as-a-whole far behind. That is, instead of studying the behavior of the human organism-as-a-whole in his social environment, we shall have attacked problems pertaining to his highly specialized parts like the eye and ear, and pertaining also to the restricted conditions under which these parts are able to function.

These more specialized and abstracted reactions fall under the heading of learning and observational behavior. To begin with, we shall examine learning, first in its grosser aspects and then in its more precise forms.

Learning Defined. We may define learning tentatively as that behavior in terms of which the individual extends his insight into a given situation and increases the complexity of his actions with respect to a certain goal. Recall that by insight we mean organized response at the level of conscious behavior.

There is something illusory about learning, so illusory that for a long time it was supposed that learning meant a simplification of behavior. For example, the first movements you made in driving an automobile seemed far more complex than your later and well co-ordinated movements. Your earlier movements were more awkward, but actually much simpler in their nature than the well learned and easier motions. But strange as it may seem ease does not mean simplicity; it means organized or configurational response, or in other words the development of insight.

Problems Pertaining to the Learning Process. How do we account for this increased insight that develops during repeated efforts? What explains the acquisition of skill at piano playing, golf or tennis? Again we seek the ultimate explanation in terms of the conditions under which the learning takes place. But what meanwhile do we find at first glance in the learning process?

(1) We find an animal or a human organism about to execute an act it has never performed before. New information and new co-ordinations of movement are to be acquired. For example, a child must learn how to read musical notes and to make appropriate finger movements on the piano keyboard. A would-be stenographer must learn to find the positions of the typewriter keys and to make accurate movements with each of her fingers in pressing those keys. A rat in a laboratory experiment must find a way to its food through a labyrinth of pathways some of which are blind alleys. In human behavior, at least, many of these tasks involve the process of memorizing.

(2) In many such situations the learner behaves in a confused fashion at first. The human learner, for instance, grapples blindly with his problem and both the animal and human being make inappropriate movements. It is generally but erroneously assumed that these 'mental' grapplings and the making of random movements constitute a necessary first step in the learning process. Out of those that *by chance* happen to be successful the correct ideas and movements are said to be selected. Then the problem arises, what selects them? What, for example, leads the rat to avoid blind alleys into which he previously entered? What leads the typist to abandon the searching movements of her fingers? What leads the student to correct a misconception he had in regard to a law of economics? These are problems that will be considered in this and the next two chapters.

(3) We find that learning proceeds under a great variety of conditions many of which can be controlled. Here are a few of the more important ones:

(a) The goal.
(b) The difficulty, length and precision of the task.
(c) The method of presenting the task.
(d) The emotional character of the learning.
(e) Number and distribution of trials.
(f) Time relations of different tasks.

We shall be engaged, also, during the next three chapters, in ascertaining how a control of these conditions enables us to determine the efficiency of the learning process.

The Goal as a Condition of Learning. That learning always takes place with reference to an end has already been implied. For example, animal learning always occurs with reference to the goal of food, a sex object, or a safe place to hide. In human learning the goals are far more complicated and numerous, having to do in daily life with earning a living, recreation and achieving social status. Yet, all details of a given learning process are features of a single, unified response directed at once by a stimulus-pattern, part of which is environmental and part of which is conditioned by the organ-

ism's structure. This stimulus-pattern contains a *locus* which is the objective, the goal, for example food in the case of the hungry rat running a maze. It is to be supposed that conditions within the organism determine at the time what the locus of any particular stimulus-pattern will be. In this case physiological factors producing hunger contractions constitute these conditions. At another time these conditions may be a healthy state of the sex organs together with the presence of a sex object. The sense organs of sight, hearing, smell and so on, are other organic conditions, to which should be added the general state of development of the organism's muscular and nervous system. Given these conditions and an external stimulus-pattern with its locus, the stage is partly set for action.

The Goal as an Anticipated Object. But this is not all; the goal need not be present as a sensed object; it may be present as an *anticipated object* (cf. page 151). That the lower animals imagine the anticipated goal can not be demonstrated directly, yet it is obvious from observation that they behave with respect to a goal. The hungry animal hunts for food; the frightened animal flees from the odor of an enemy coming down the wind, although the enemy is not seen; the bird flies back to its young and the bee to its hive. Presumably the hungry rat, searching for food, perceives the goal in some lowly fashion; possibly he imagines it. Not long ago such a view would at once have been condemned as 'anthropomorphic' (a prejudiced interpretation of animal behavior in terms of human experience), but in the light of the configurational hypothesis the criticism is irrelevant. If the lower animals respond to objects in their relations, although in a simpler way than human beings, it is to be expected that their representation of goals bears a resemblance to the human being's. Ascribing imagination to animals does not involve us in anthropomorphism if we are careful in stating what animals imagine and what relationships the imagined goal sustains to the total behavior of the organism. We might as well suppose that animals can imagine the sight and smell of food as to assume their ability to see and smell food when the latter is within range. We do not, however, need to suppose

they imagine the goal in the multitude of relationships that human beings can. These relationships in animal behavior are for the most part spatial and concrete, while in human behavior they may be more complex, even logical and abstract. At any rate if we are to assert that animals search for food, or carry on any activity whatever with respect to remote and unseen ends, as they obviously do, we can not escape the problem of explaining how these goals function. At least we know that human beings perceive goals with the use of imagination and language. They will orient themselves with respect to these goals by the same means. Behavior of this sort is thinking and is often voluntary, or consciously purposeful; the individual is aware of the goal, as such.

The structural conditions within the organism, together with the external pattern and its locus observed directly through the senses or indirectly through imagination, roughly complete the stage for action. What happens then, according to the conditions of least action, has already been described in a general way in previous chapters (page 125). It may be concluded, therefore, that the goal is one of the major conditions of learning. This conclusion may be illustrated further by a recourse to the facts of systematic observation.

Importance of Definiteness of Goal in Learning. Obviously if the goal is vague, learning will be proportionately ineffectual, for there is nothing definite toward which the organism is reacting, nothing definite to direct the organism's behavior. This frequently happens in animal experimentation. When an animal is placed in a situation too complicated for it to perceive the goal set by the experimenter, *it seeks goals of its own.* Frequently it sees the situation with respect to the goal of escape, perhaps of returning to its cage. It may see the apparatus as something to explore, or it may ignore the apparatus, sit down and wash its face and clean its fur, or it may sit inactive. It is likewise with a human being. If the goal is too difficult for him to perceive, or only partially within his insight, he will either give up the task or supply goals of his own which are inadequate and possibly irrelevant with respect to the goal intended by the experimenter. The resulting efforts to learn may then be called

trial and error attempts, but only with respect to the *imposed* goal.

The Will to Learn. In human learning definiteness of purpose is in part conditioned by the explicitness of instructions given the learner to fulfill. This is so obvious a fact that illustrations are unnecessary. Definiteness of purpose may, however, be seen in other lights, for example with respect to the will to learn or intent to remember. Years ago Ebbinghaus [1] gave himself a list of meaningless syllables to learn which he repeated over and over again with little intent to remember them. At the end of 50 repetitions he could recall scarcely a single one, but when he set himself vigorously at the task he learned twelve syllables in as many repetitions!

Peterson [2] once performed a rather interesting experiment on a class in psychology. He presented lists of words to two groups of students. One group listened to the words passively with little if any intent to remember them and the other group listened under opposite conditions. Immediately after each experiment he asked for a recall and again after two days. The effect of intent was to increase immediate recall 22 per cent and delayed recall 50 per cent. The intent had a much greater influence, therefore, on delayed than on immediate 'reproduction,' but in either case the effect was striking.

Knowledge of Results as a Supplement to the Goal. Many experimenters have demonstrated the influence of knowledge of results upon learning. Book and Norvell [3] instructed an experimental and a control-group to learn a code, to multiply figures mentally and to perform other simple tasks. They asked the experimental group to watch its records carefully and made the group feel if possible that it could increase its score with every practice. On the other hand they did not permit the control group to know its progress. *The experimental group improved more both in speed and in accuracy than the controls. When the incentives were given*

[1] Ebbinghaus, H., *Memory* (Tr. Ruger). New York: Teachers Coll., Columbia Uni., 1913 (Original date, 1885).

[2] Peterson, J., "The Effect of Attitude on Immediate and Delayed Reproduction. A Class Experiment." *J. of Educ. Psy.*, 1916, Vol. 7, 523–532.

[3] Book, W. F., and Norvell, L., "The Will to Learn." *Ped. Sem.*, 1922, Vol. 29, 305–362.

to the controls and taken away from the experimental group the latter suddenly ceased to gain and the former suddenly improved (see Figure 22).

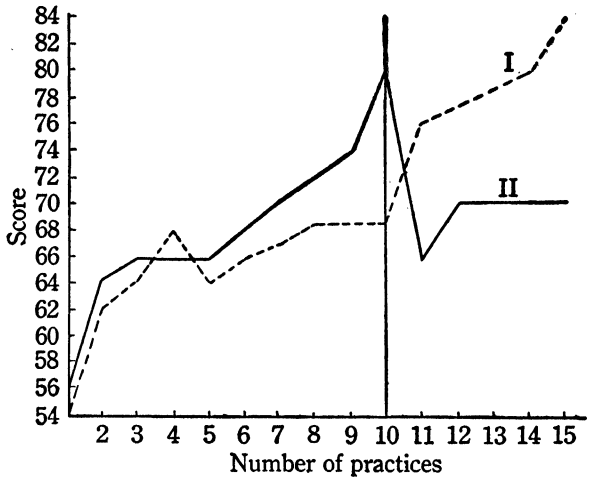


FIG. 22. LEARNING CURVES SHOWING THE EFFECT OF KNOWLEDGE OF RESULTS (Book and Norvell).

At the tenth practice the incentive was taken away from the experimental group (II) and given to the control group (I). Notice the decline in the performance of the experimental group and the sudden improvement in the control group.

FACTS SUBSTANTIATING THE LAW OF CONFIGURATION

(1) Rote *versus* Logical Memory. The law of configuration applies when a person makes repeated observations of the same material with a view of remembering what he has observed. To illustrate, Table VI contains three sets of memorial material. It is illuminating to ascertain the time required to memorize each of the three lists and to measure the amount of effort in terms of repetitions. Read through the list completely each time.

A subject to which the author submitted these lists required twelve repetitions (about six minutes) to memorize the first one, four repetitions (two minutes) to learn the second and only one repetition (fifteen seconds) to learn the third. He learned the first list almost mechanically, by rote. It was

TABLE VI

MEMORIAL MATERIAL DEMONSTRATING THE LAW OF CONFIGURATION

1.	2.	3.
gub	cow	room
tej	sun	floor
soh	fir	wall
biq	pet	ceiling
maf	tan	door
cug	boy	window
por	lip	chair
vel	tub	table
wix	red	couch
yan	has	pillow

not sheer repetition, however, which enabled him to memorize it; he learned each syllable in its *spatial relationships* to other syllables in the series, especially to those adjacent to it. These spatial relationships were important factors of insight, limited though the latter was. And it was precisely this limitation which made him take so long to learn the series. The syllables had little if any meaning beyond the fact that they were syllables, located in different positions in the series and having different sounds. The subject proceeded much more rapidly with the second list. He not only apprehended each word in its spatial relationships but in many others as well. As he perceived each word he recognized it and thought of the objects represented by the words. As a consequence of seeing each word in larger and more detailed relationships he learned them more rapidly. He memorized the third list in one repetition, for he perceived each word in a definite relationship to the entire list. Indeed, the entire list formed a unit; it referred to a single but complex situation and each word, in the perceiving of it, became a member of a configuration. To put it differently, he apprehended each word in its relation to a 'principle.' This explains the rapidity with which he memorized the words.

Not only did the subject learn the lists at strikingly different rates, but he remembered them over a period of time with equally striking differences. At the end of a half hour he could recall only four of the meaningless syllables: por, maf, vel, wix, but not in their correct order. He reproduced the

second list correctly save for *tub* which he remembered as *tug,* and he took about three minutes for the recall. In less than thirty seconds he reproduced the third list without a single error, only hesitating once between 'ceiling' and 'door' to satisfy himself that 'door' came before 'window'!

(2) Whole *versus* Part Methods of Memorizing. Other things being equal, it is easier to learn memorial material by studying it as a whole than by dividing it into parts and learning each part separately. The whole method makes better use of the principle of configuration. Most learners violate this principle and suffer the many consequent disadvantages. *First,* when they attack a poem, for example, they proceed to memorize the first stanza then the second, and so on. They find in this method an illusory evidence of progress at the outset. What, they think, one stanza learned already! But they forget that after they have learned all the stanzas in this fashion they still face the task of putting them together, a procedure which requires a great amount of time in repeating over again the material learned as isolated units. *Second,* they waste time as they go along by missing the thread of the story. Had they availed themselves of this continuity it would have helped them considerably. As it was they denied themselves the possibility of seeing the material in its wider relationships. *Third,* they are likely to learn separate sections with a distorted conception of their relative importance. This follows from missing the continuity of the whole. As a result, they may confuse the order of the material, follow wrong cues and perhaps leave out sections entirely when the time comes for the recall.

Experimental Studies of Learning by the Whole and Part Methods. Perhaps the earliest emphasis upon the whole method of learning, made on the basis of experimental results, may be found in Ebbinghaus'[4] first rule of memorizing which he set forth in 1885. In 1904 Ebert and Meumann,[5] working on children, concluded that the greater the number of parts into which memorial material is divided, the less

[4] *Op. cit.*

[5] Meumann, E., "Ueber einige Grundfragen der Psychologie der Uebungsphänomene im Bereiche des Gedächtnisses. *Saml. von Abhandl. zur Psy. Päd.,* 1904, Vol. 1, 437–668.

economical is the method of learning. However, in case of meaningless material the advantages of the whole method did not become evident. Contrary to the results of other investigators Meumann held that in adults the whole was preferable to the part method, even in case of nonsense material, unless the subject's interest lagged as he was observing the material in the middle of the selection. On the other hand, Ephrussi (1904) [6] found that the whole method was better for familiar material and the part method for unfamiliar material.

In 1911, Pyle and Snyder [7] found that their subjects learned better by the whole method whether they were given 5 or 240 lines of poetry to memorize. Twenty to 50-line units furnished a saving of 11 per cent over the 5-line unit, in amount recalled at a subsequent date. Sixty-line units furnished a saving of from 20 to 22 per cent, 120-line units a saving of 17 per cent and 240-line units a saving of 20 per cent.

In 1917, Pechstein [8] found that the whole method was not the best for maze learning, althought it was superior to the part method of learning the same type of task. First, his subjects learned a maze divided into four sections. In one experiment they learned part 1, then parts 1 and 2, then parts 1, 2 and 3 and so on, which he called the *direct repetitive method.* Second, they learned the maze by a *reversed repetitive method,* section 4 first, then 3 and 4, then 2, 3 and 4 and finally all four. Third, his subjects learned the maze by the *progressive part method,* section 1 alone, then 2 alone, then with 1 and 2 connected and so on. He found that both the progressive and direct repetitive methods were superior to the whole method. Recently the same author [9] established that in learning poetry the progressive and repetitive part methods were more effective than whole methods and that learners of high intelligence were able more successfully to use

[6] Ephrussi, P., "Experimentelle Beiträge zur Lehre vom Gedächtnis." *Zsch. f. Psy.,* 1905, Vol. 37, 56–103, 161–234.

[7] Pyle and Snyder, "The Most Economical Unit for Committing to Memory." *J. of Educ. Psy.,* 1911, Vol. 2, 133–142.

[8] Pechstein, L. A., "Whole *versus* Part Methods in Motor Learning: A Comparative Study." *Psy. Mon.,* 1917, Vol. 23 (No. 99).

[9] Pechstein, L. A., "The Whole *versus* Part Methods in Learning." *Stud. Educ.,* 1926, No. 15, 181–186.

the whole method than persons of lower intelligence. In general this substantiated earlier findings that the whole method proved more satisfactory with familiar material than the part method.

Sawdon [10] has discovered additional qualifications of the rule that the whole method is superior. The subjects in this investigation were boys of the same intelligence. The whole method proved to be superior when the memorial material (poetry) was easy, rhythmic and had running through it a definite story. Its superiority did not appear, however, in difficult passages. When the individual was given sufficient time even with longer poems the whole method was the better, but with short time-limits the part method excelled. Midway between long and short time-limits the two methods were of equal value. These results confirm earlier findings that for ordinary material, requiring some time to learn, the whole method is better both for accuracy of immediate recall and for completeness of later recall.

We must distinguish, evidently, between relatively meaningful and relatively meaningless tasks. The whole method seems clearly to be less adapted for unfamiliar and meaningless tasks; because the subject matter as such can not be apprehended as a whole, due to its lack of unity. Under these conditions the learner must respond to various parts as wholes by the part method or some modification of it. Then he must rely upon an apprehension of the less meaningful relationships between the learned parts, such as the spatial and temporal, before learning the task as a whole. There is nothing lost in this procedure because there are no part-whole relationships to be missed; there is something to be gained because otherwise the individual would waste time trying to grasp the material as a whole when there was no meaningful whole to be grasped.

But no study that gives to the animal or to the human subject meaningless tasks to perform will yield results of far reaching significance. The facts of behavior in artificial [11] or

[10] Sawdon, E. W., "Should Children Learn Poems in Wholes or in Parts?" *Forum Educ.*, Vol. 3, 1927, 182–197.

[11] By artificial conditions is meant such a combination of conditions

meaningless situations are not sufficiently complete to be of service in understanding behavior under natural and meaningful conditions because *the subject responds best to sensible situations.* Behavior must be explained by the conditions under which it takes place; if they are unnatural the behavior will be unnatural also; one can not reason safely from unnatural to natural conditions. If children fail to learn meaningless material readily by the whole method, or if the feeble-minded do not learn readily by the whole method, it can hardly be concluded that some modification of the part method is better for learning in general. Rather, *when the task is properly articulated with the insight of the learner the whole method is better.*

The Mediating Method. Very rarely if ever is there a mass of material to be learned which is of equal difficulty throughout. When difficult passages appear, the learner should of course devote extra time to them, but always with the purpose in mind of understanding what makes these passages difficult and what relationships they sustain to preceding and following sections. In other instances the learner may undertake material which is too long to attack by the whole method. Then he should divide it at logical breaking points and study the divisions as wholes, not losing sight of their significance with respect to the entire mass of material. These procedures are classified under the *mediating method;* it is the whole method judiciously applied.

(3) Rate of Learning *versus* Rate of Forgetting. Contrary to popular opinion the person who learns rapidly is usually the one who remembers the most material. There are several reasons for this: (a) The rapid learner is one who employs the better methods that work for a more thorough mastery of the material. (b) He learns faster, with greater insight into the task. Moreover, the more insight he brings to bear upon the material the greater amount of it he remembers. (c) He apprehends more detail which gives him an opportunity to perceive the material in a greater variety

as introduce irrelevant responses, defeat the intent of the experiment, place the behaving organism at a disadvantage, or never occur in the ordinary run of events.

of relationships. In case of unfamiliar material, where there is less opportunity for the apprehension of relationships, the slow learner who spends more time establishing relationships between details forgets less than the rapid and superficial learner.

(4) Lewin's Test of the Configurational Theory. Additional evidence of the law of configuration appears in a study by Lewin [12] who gave a group of learners various tasks such as sketching, printing names and assembling puzzles. In certain instances he interrupted the learners before their tasks were completed; in other instances he permitted them to finish. Later he asked his subjects to recall what they could of their performances. He obtained the surprising result that adults remembered the uncompleted tasks 90 per cent better than the completed ones; children remembered the uncompleted tasks almost exclusively. Evidently once the task is set up it demands completion and interrupting it leaves the individual in an unresolved tension. His better memory under these conditions is probably an effort to complete the task. On the other hand, when the task is completed there is an unresolved tension only to the extent that the learner intends to remember what he has done.

Summary. The experimental work studied up to this point emphasizes two important conditions of effective learning: *first,* the perception of a goal and *second,* selecting material or situations that will be sensible to the learner. The goal should be as definite as possible and the task should be of a length and difficulty that permit the whole method of learning. Insight proves to be an important feature of learning, and the evidence shows that learning and remembering, like other forms of behavior, are configurational responses.

The Relation of Emotion to Learning

Emotive Behavior in Relation to Learning. It is only in a practical sense that we can speak of feelings and emotions

[12] Lewin, K., "Untersuchungen zur Handlungs und Affektpsychologie III." Zeigarnik, B., "Das Behalten erledigter und unerledigter Handlungen," *Psy. Forsch.,* Vol. 9, 1927, 1–85.

as incentives to learning, for if we wish to be exact in our description of behavior we find that the *instant a person exhibits feeling and emotion in a learning situation, the learning process has already commenced.* The feeling and emotion, under these circumstances, are aspects of learning behavior. Since the conditions of the learning are those which arouse the emotion it is arbitrary to separate the emotion from the learning, although this does not mean that emotionalized learning is identical with indifferent learning. In spite of this fact we commonly regard the feelings and emotions as motives, or as separate factors in learning. Thorndike's theory is an illustration, for according to him the pleasure and satisfaction attending success or reward so vivify the impressions of the moment that the latter are more readily retained. Unpleasantness and annoyance, accompanying failure and punishment, have an inhibiting influence on the performances with which the unpleasantness is associated.

To suggest a substitute interpretation, when you train your fox terrier to sit up and beg, you reward him with a tidbit not thereby to vivify the muscular sensations of making the correct movements, but in order to provide the dog with a definite goal with respect to which it will execute the desired act. Dog-fashion, it will then understand what you want of it, for responding with respect to food-goals falls well within the repertoire of dog-insight! Dog-insight is relatively feeble and slow of development, especially under artificial conditions, consequently considerable time will elapse before it will make its movements just as you want them. Meanwhile it is making numerous other movements all at about the same time, jumping, barking and running around; which of these is to function ultimately as the 'tool' (cf. page 126) for the securing of the food is the difficult problem you have imposed upon it. As the dog keeps trying, its insight into the situation grows, just as the human being on a higher plane solves a mathematical problem by continued performance with respect to a definite goal.

Punishment is to be explained in a similar fashion. The trainer whips a bird dog when, on retrieving, it mashes the pheasant. According to Thorndike discomfort lessens an

association between the sight of the bird and the jaw-contractions of biting into it. But this theory fails to take into account the fact that the dog must not only relax certain muscles of its jaw; it must also contract others in order to release the bird. In terms of the theory, therefore, the whipping must incite as well as inhibit certain contractions, a double function of punishment which the theory does not cover. Moreover, if reward is to have the specific effect claimed for it by this theory—that of strengthening certain contractions—it too must have the same double function, for to make certain movements means also to inhibit others. To summarize, punishment is applied to furnish a goal for the animal's behavior; it creates a special stimulus-pattern on the dog's level of insight. The goal is a situation to be avoided; carrying a bird gently comes to be the means by which the goal is avoided.

The same principles are applicable to child behavior, but here the circumstances are more complicated. Rewards and punishments become goals, but frequently undesirable ones, because the relationships in which the child will apprehend the goal are often unpredictable. For example, upon Johnnie's confession his father whips him for lying. But just at that time Johnnie was thinking that he should not have told his father. Will Johnnie apprehend the punishment as a reprimand for lying or for telling that he lied? From the standpoint of an adult such an error would seem absurd, but in terms of child-insight it might be the more sensible conclusion!

For a long time the author attempted to make his small daughter submit agreeably to a nose and ear cleaning before she went to bed. He punished, but to no avail; he offered rewards. "Lois, if you will not cry this time, you may play lion with me for five minutes." But no reward would bring results. The way out of the difficulty came almost by accident. As the father was rolling up a corner of the face-cloth one night, Lois squirming and fretting as usual, he said, "Now let's play spear. One, two, three, spear." Whereupon he jabbed the corner of the face-cloth suddenly into one ear, his fingers hitting the ear with a thud. Subsequent rubbing, which must have hurt more than usual, failed to dismay her. She chuckled with delight and said, "Daddy, do it again."

The goal was its own reward; thereafter she volunteered to have her nose and ears washed. The goal was to play the game; it was thrilling action; standing still before the wash basin was a means of attaining the goal.

Unfortunately many rewards given with the best of intentions become undesirable goals. Rewarding with candy leads to an uncontrollable taste for sweets; the purchasing of rewards leads to the anticipation of a present each time the father and mother leave the house. Moreover, rewards may prevent the child from apprehending the real reason for the behavior required of him especially if the behavior involves social relations. Repeatedly telling Johnnie that if he will not strike his younger sister he may have a cart for his birthday does not teach Johnnie to be gentle. It may either induce him to 'work' his parents or give him the desire for expensive toys, or both. To learn gentleness he must observe it in its relevant social relations. One method would be to take Johnnie aside quietly and say, "Now when you strike sister it hurts like this." Another method would consist in asking him if *he* wants to be struck and in reasoning with him further. In any case the end to be reached is Johnnie's understanding of others' feelings, not an inflation of Johnnie's ego by making obedience a means of securing more attention.

Unfortunately, also, ulterior motives abound in our educational systems, even in our colleges. Grades, grade-points, grade standards, honors and the like, all detract from the real purpose of an education. They contribute much to the deplorable fact that students work just to 'get by' or work for standing in the social group rather than for the value to be received from study itself. These ulterior motives hide the goal of knowledge for its own sake.

Memory for Pleasant and Unpleasant Experiences. The problem, What is the relationship of feeling to memory and learning? was not made easier by the belief, emanating without justification from psychoanalytic literature, that we repress and forget the unpleasant and remember the pleasant. Quite possibly we do, but it is our business not only to discover and deal with facts; we must also explain them, understand them. It is one thing to say that we forget the unpleasant but

it is entirely another thing to assert that the unpleasantness causes the forgetting. *It would be much safer to assert that we forget those unpleasant events which we want to forget, provided we have sufficient knowledge into the means of forgetting them; also that we remember those unpleasant experiences which we are able to see are to our advantage to remember.*

Interpretation of Emotion in Relation to Learning. If we couple with the facts from experiment, evidence from child and animal behavior that so-called motivated learning is the rule rather than the exception, we face the problem of interpreting learning partly at least in terms of emotive behavior. Since we have said that it is incorrect to single out emotions from learning, and to regard the former as conditions of the latter we must seek the efficacy of 'motives' in the conditions which arouse the unified emotively toned response.

In Chapters VII and VIII we discussed the two general conditions of emotive behavior. *First,* there are stimulus-patterns which arouse intra-organic tensions together with tensions of the voluntary neuromuscular system. *Second,* there is an organic structure composed of an autonomic nervous system, a digestive tract and a chain of glands which furnish the organism with internal stimulation. When these conditions function in a learning situation, *emotive learning* occurs, a learning which in part derives its persistence and speed from a more vigorous functioning of the neuromuscular system. According to the conditions of least action the tensions thus set up will demand a more rapid return to a state of equilibrium. *In other words motives do not explain learning; they are aspects of the faster and more persistent learning that follows from increasing the learner's tension.*

Methods of Measuring the Relative Strength of Different Tensions. Various investigators in the field of animal behavior have devised methods of measuring these tensions. In 1920, Dashiell[13] reported an extremely simple method of measuring the activity of rats suffering from different degrees

[13] Dashiell, J. F., "A Quantitative Demonstration of Animal Drive." *J. of Comp. Psy.*, Vol. 5, 1925, 205–208.

of hunger. He used a large checkerboard of interconnecting 'blocks' into which he placed the rat. He then measured the rat's exploratory behavior by the number of intersections it traversed in a given amount of time. Figure 23 is a diagram

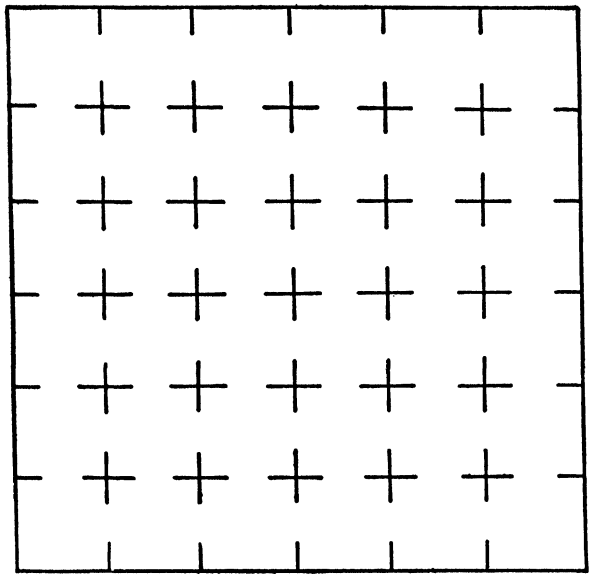


FIG. 23. THE DASHIELL 'CHECKERBOARD MAZE' FOR MEASURING HUNGER TENSION IN RATS.

of the apparatus and Table VII shows the difference in activity between hungry and non-hungry rats.

TABLE VII

NUMBER OF BLOCKS ENTERED BY ANIMALS OF TWO GROUPS

Fed	Hungry
20	34
29	36
9	37
24	47
31	42
The averages for 17 rats:	
26.7	42.9

In 1922, with the use of a simple four-choice box, Kuo [14] measured the relative effects, upon learning, of a short path to the food, a long path to the food, confinement for twenty seconds within a compartment and an electric shock. His apparatus is shown in Figure 24. He used four groups of rats with a different spatial arrangement of compartments for each group. A hungry rat was placed in a chamber at S. In front of the animal was a row of four doors leading into the four compartments. If it chose compartment 1, for example, the experimenter opened the rear door, kept the door at D2 closed, opened the door at D1 and gave the animal access to food at F1. This was the short path. If the rat chose compartment 2 he closed the front door and confined the animal there for twenty seconds. If it chose compartment 3 he gave it an electric shock sufficient to hurt, but not to injure it. If it chose compartment 4 he opened the rear door, kept D1 closed and opened D2, permitting the animal to find food at F1 by the roundabout alley.

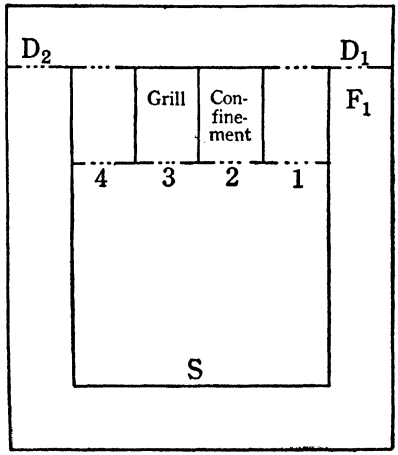


FIG. 24. KUO'S MULTIPLE CHOICE BOX FOR THE STUDY OF THE ELIMINATION OF UNSUCCESSFUL ACTS IN ANIMAL LEARNING (Explanation in Text).

His rats eliminated the electric shock compartment first, the confinement box second, the long-path compartment third, so that finally they chose only the short-path compartment. *The order in which the rats eliminated the three routes was independent of the frequencies with which they had traversed them. Moreover, they suddenly forsook undesirable routes, a procedure which may be considered a criterion of insight.* Of course there were many individual differences between rats, but on the whole these results substantiate the hypothesis

[14] Kuo, Z. Y., "The Nature of Unsuccessful Acts and their Order of Elimination in Animal Learning." *J. Comp. Psy.*, Vol. 2, 1922, 1–27.

that the short path was finally learned because it satisfied the conditions of activity in the direction of least action. The rats were behaving under tension; they were hungry. Other things being equal their choice of the shortest route was an illustration of the law.

A General Law Pertaining to the Goal. That frequency was not a conditioning factor and that the rats eliminated wrong choices suddenly are facts consistent with the view that the animals responded to each compartment in its relation to the food-goal. We may state as a general fact that *whatever object or situation at the time relieves the most tension, or best balances the tensions is the goal which directs the organism's activities.* That a single goal does not become operative at once means that there is a conflict of goals. For example, in Kuo's experiment certain of the rats never eliminated the long path for reasons the specific nature of which can only be conjectured. It is possible that these rats reacted to the long-path compartment in a relationship undetected by the experimenter.

Further Measurements of Tensions. In 1924, with a much simpler method, Moss [15] measured the relative tensions induced with respect to different goals. Figure 25 shows his apparatus. He placed a rat in chamber *A* and food or a sex object (rat of opposite sex) in chamber *C*. In order to go from *A* to *C* the rat passed over a live electric grill. The amount of voltage necessary to inhibit the animal's approach to the goal measured the amount of striving or tension toward that goal. Figure 26 shows the percentage of rats who submitted themselves to a twenty-volt shock in order to get food, after starvation periods of different lengths. Moss also ascertained that a seventy-two hour hunger tension more often than a sex tension led the animal to cross the grill at twenty-eight volts; that the female would overcome

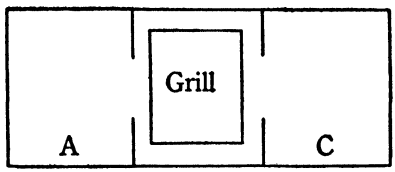


FIG. 25. APPARATUS FOR MEASURING ANIMAL TENSIONS (MOSS)

[15] Moss, Fred A., "Study of Animal Drives." *J. Exper. Psy.*, 1924, Vol. 7, 165–185.

more resistance to secure sex gratification than the male; that females would not cross the grill to their newly born litters on the other side so readily as other rats had done in securing food after seventy-two hours of starvation.

In 1926, Washburn [16] performed an interesting experiment in which she correlated speed of running the maze with the length of time mice spent eating after they had reached the food. Certain animals showed a high correlation and others did not. She also found that *those animals showing a*

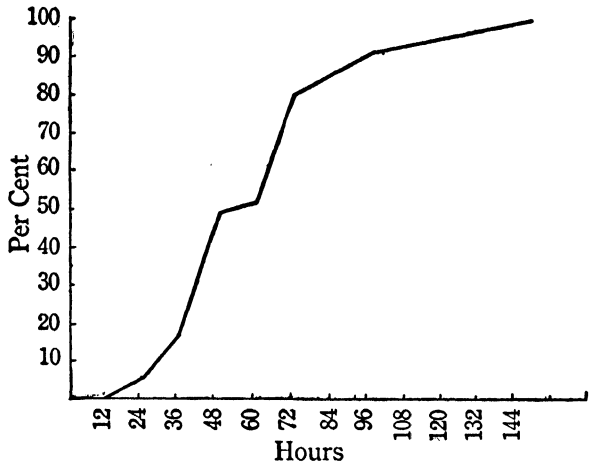


FIG. 26. CURVE SHOWING THE RELATION OF HUNGER TENSION TO NUMBER OF HOURS OF STARVATION AS MEASURED BY PERCENTAGE OF RATS THAT CROSSED LIVE GRILL (MOSS).

high correlation between length of eating-time and speed of running made fewer errors in reaching the food. Animals that ran fast but ate little made more errors. And finally she discovered that degree of hunger did not eliminate individual differences in 'general learning ability.' That is, hunger-driven animals that were poor learners usually failed to excel other animals that were less hunger driven, but learned faster in general. Again these individual differences bear out the view that tensions are established and resolved in the form

[16] Washburn, M. F., "Hunger and Speed of Running as Factors in Maze Learning in Mice." *J. Comp. Psy.*, Vol. 6, 1926, 181–188.

of configurational responses which the term, insight, serves well to describe. An interesting but less definite method of measuring 'incentives' was reported in Simmons' [17] study with white rats, in 1924. She found that the rats learned the maze to some extent with escape as the evident goal, but upon the introduction of a food or other new incentives they showed a pronounced and sudden learning.

Kitson [18] has measured the consequences of increased tensions in human beings in his study of the improved efficiency of forty hand compositors at the Lake Side Press, Chicago. After examining their output under ordinary conditions he measured their progress under a special bonus system and under the incentive of knowledge of daily score. The average trade experience for these men was 10.3 years and yet, under the new system, their efficiency increased on the average from 58 to 97 per cent in 20 weeks. One man who had been a compositor for 27 years made a gain of 142 per cent. Another, of 14 years' experience, improved 282 per cent! The most experienced half of the group increased their output 50 per cent and the least experienced half made a gain of 75 per cent. The obvious reason for the improvement of these men was a change in working conditions which gave them more insight into their task and stimulated them into more vigorous activity. They were working toward a more effective goal.

These studies demonstrate that 'drives' are not special mechanisms acting upon the learning process. On the contrary, different forms of learning involve procedures whereby tensions of varying degrees of intensity are resolved under the direction of a goal according to the conditions for least action. These varying tensions are the phenomena often unnecessarily abstracted from the learning process as instincts and drives. *It may be concluded, therefore, that feelings and emotions are not, as such, conditions of learning, but that much of learning is conditioned by the same factors as account for emotive behavior.* For that reason, the same activity may be described either as emotive or as learning behavior or as both.

[17] Simmons, R., "Relative Effectiveness of Certain Incentives in Animal Learning." *Comp. Psy. Mon.*, 1924, Vol. 2.

[18] Quoted by Book and Norvell, *op. cit.*, 308.

The Problem of Association

Introduction. In dealing with the goal as a condition of learning, we have been implying insight. We have also implied the fact of insight in our discussion of emotion in relation to learning, for we said that emotion, as such, was not a condition of learning. Rather, a goal is set up which induces greater tension than in the case of unemotional learning. The difference in the character of the goal and the tensions aroused constitute the difference in the two varieties of learning. Both require the development of insight. In short, emotion, however aroused, is ineffective in learning if the goal is inadequate and insight is lacking, that is to say, if conscious responses are not organized with respect to the goal.

Association as an Attempt to Explain Insight. It is a commonplace fact that learning involves a growth of insight, for the learner is able to execute more complicated performances as he repeats the task; he perceives a more complex and definite goal. How does the individual gain his insight? Here we encounter a difficult problem which as yet we have solved only superficially by referring it to the extent of evolutionary development of the organism and to the degree to which it has matured in its life history. What purported to be an adequate answer to this question is found in the theory that we learn by experience. Nearly everyone accepts this statement as fact; it is common sense! But it is not so adequate as it seems on first thought.

The experience-theory is an application of the famous, historic concept, association. This theory supposes that we learn gradually by associating together various elements of a situation according to the *law of contiguity,* namely, that any two experiences that have occurred together will be likely to occur together again. The original simultaneous occurrence depends either upon the simultaneity of stimuli or upon their immediate temporal continuity. To illustrate, a child sees a dog and at the same time hears the name, dog. Thereafter the sight of the animal tends to suggest the name or the name reminds the child of that particular animal. There were sup-

posed to be many special cases of the law of contiguity. Important among them were association by contrast, similarity and cause and effect. In recent years the more important of the special or secondary laws of contiguity have been stated as follows:

1. *The law of frequency.* Those experiences which are the most often repeated under conditions of contiguity are the best remembered. Hunter [19] restates it in terms of nerve physiology thus: "If a nervous pathway is frequently traversed its resistance is decreased so that the nerve impulses pass over it more and more readily." Watson [20] applied this same principle to the acquisition of new muscular co-ordinations both in animal and human learning. Thorndike [21] restated it and made of it a basic law of learning, *entitled the law of use or exercise.* When a given stimulus arouses a certain response there is a certain connection or bond between them that is strengthened by the exercise so obtained, implying, of course, contiguity between the experiences concerned with both the stimulus and the response. This law is the basis of the popular notion that repetition of a performance produces habit and is the theoretical foundation of all drill.

2. *The law of recency.* Other things being equal the last things to have been experienced together, or the last movements to have been acquired together are best remembered. According to Hunter [22] if a nerve has been used recently it is still in a condition favorable to the repassing of nerve impulses over it. Superficial experiments have seemed to show, for example, that when one is learning a series of words he remembers more readily the last one or two of the list than those in the middle. But more careful experiments yield contrary results.

3. *The law of vividness.* Objects and events which make the most vivid 'impression' at the time they are observed are

[19] Hunter, W. S., *General Psychology,* Rev. Ed., Uni. of Chicago Press, 1923, 303.

[20] Watson, J. B., *Psychology from the Standpoint of a Behaviorist.* Philadelphia: Lippincott, 1919.

[21] Cf. Thorndike, E. L., *Educational Psychology,* Briefer Course, Teachers Coll., Columbia Uni., 1914, I., 161 ff.

[22] *Op. cit.,* 303.

most likely to be recalled. Hunter [23] explains that in some way the neural processes underlying vivid experiences serve to aid certain other neural processes on the one hand and to inhibit them on the other. Generally these are such as are associated with feeling and emotion. Thorndike [24] has modified this law and made extensive use of it under the name, *law of effect.* The bond between a response and a stimulus is strengthened when the response is a success, and is weakened when the response is a failure, or in other words, successful performances furnish a pleasure which stamps in the act, and unsuccessful performances furnish an annoyance which stamps out the act.

4. *The law of intensity,* which is supposed to be different from the law of vividness, states that the more intense the stimulus the more likely the response to it will be remembered. Vigorous exercise strengthens a reaction more than weak exercise. Accordingly, the principle has been regarded as a sublaw of exercise.

5. Hunter would add the law of intellectual congruity, or the *law of the Aufgabe.*[25] The purpose of the moment, or goal idea, fixes the limits within which associative sequences of experiences will take place at any given time. Suppose you are given instructions to think of a word whose meaning is the opposite of a stimulus word which you will soon read. Think as quickly as possible of the opposite. Ready, here is the word: 'Hot.' Why did you not think of grass, or knife or some other word? According to conventional psychology the *Aufgabe,* or task-consciousness, directs your train of associations. Only such associations will appear as harmonize and are consistent with the instructions of the moment.

These means of accounting for the elimination of wrong responses were required by the assumption that learning began with unorganized experiences and movements. The same assumption made it necessary to explain by a similar means the fashion in which those associations and movements that turned out accidentally to be successful were selected and established

[23] *Op. cit.,* 303.
[24] *Op. cit.,* 125 ff.
[25] *Op. cit.,* 305.

as habits. All these laws were attempts to explain the development of insight which, in the view of the text, is never a matter of unorganized experiences and movements from the standpoint of the behaving organism. We shall see later that the laws of association are inconsistent with the physiological principles that underlie behavior (page 491).

Psychologists realized long ago that association in itself was not an explanatory principle. Since that time the term has been used for the most part merely to signify that all events of behavior, whether regarded as events of consciousness or events of overt action, followed one another in orderly and in integrated sequences. This is called *successive association.* The same concept is also employed in referring to complexes of mental processes on the one hand and to combinations of muscular movements on the other. These were regarded as complexes of elemental sensations and reflexes, respectively, types of processes known as *simultaneous association.*

One should be cautious in using association even as a descriptive concept. It is easy to assume that the primary and simplest mental processes are separate and discrete phenomena which are first experienced separately and then combined into complexes, as for example in constructing the perception of a goal according to the primary and secondary laws just mentioned. Likewise, it is easy to assume that the primary, simplest kinds of overt action are discrete (and stereotyped) reflexes which combine according to analogous laws. Both the logic of the situation and the facts are against these assumptions. The logical absurdity of trying to account for the complex in terms of the simple has already been noted (page 153). In fact the attempt to account for the simple in terms of the complex seems much more plausible in the light of our present knowledge. The procedure was premature by means of which the facts leading to the laws of association were ascertained. The individual was not studied first as a whole to discover the laws of his behavior as a total organism.

History of Association. Observations leading to the laws of association were made by a group of British philosophers and psychologists of the 17th and 18th centuries,

who have been called the British Associationists. They attacked psychological problems with the philosophical presupposition that all knowledge begins in discrete bits of experiences known as 'sense impressions.' Mind for these philosophers was therefore an organization of these fixed elements, including ideas, feelings and 'acts of will.' But how did they become organized? How did they ever recur later on in an orderly fashion? These questions were answered, it was thought, by the law of association. The sequence of all mental processes other than original 'sense impressions' depended on the sequence in which the latter were first experienced. The upshot of the whole movement was the implication that man was an automaton whose 'mind' was completely determined by the order in which he happened to acquire sense experience. His mind was composed, like a mosaic, of fixed, separate elements held together and determined in their order of sequence by association. That man possessed any initiative of his own and was more than a victim of environment, or that he could invent or in any way contribute to his sense experience was almost forgotten. The factor of insight was overlooked and the purposeful aspects of human behavior were slighted throughout.

The associationists were to have a profound effect upon modern psychology, for they made many valuable and lasting contributions. Their attempt, however, to explain the complex mental processes like recollecting and thinking, in terms of the simpler and lower processes has persisted until modern times. The simpler processes subsequently came to be defined as sensations and images (revived sensations) and to be regarded as the elements of consciousness. This is known as *structuralism* and somewhat facetiously as 'mental chemistry.' Still later when an attempt was made in psychology to dispense with all reference to mental phenomena, the wording of the famous law of association was changed, but its principle was retained to account for the acquisition of co-ordinated bodily movements and complex habits in terms of elemental reflexes and conditioned reflexes. Meanwhile, credit is due the configurationists for emphasizing the fact that *association comes with learning, not before it; with experience, not prior*

to it; and with new motor co-ordinations, not as their antecedents.

Inadequacy of Association Illustrated. Suppose a rat is starved for two or three days and placed in one end of a maze with food at the opposite end. The maze contains several blind alleys. The rat is hungry and is therefore active, but according to the trial and error conception of learning, based upon the laws of association, he has no definite goal. His movements are not organized; they are random. He wanders first into one alley and then another until, by chance, he discovers the food. According to the law of recency the last movements made in reaching the food will be remembered; according to the law of effect they will be retained because of their satisfying character. The rat is removed and placed again at the starting point of the maze. According to the laws of effect and recency he is now more likely to make correct movements toward the food. In terms of the law of frequency, movements into blind alleys drop out through lack of repetition. Finally, all random movements are eliminated and the animal travels directly from the starting point to the food. Throughout, the rat has been a passive victim of mechanical agencies. No insight is granted the animal; he needs none; his activities are the direct outgrowth of repetition, the factor of contiguity, and pleasure and displeasure.

It might be argued that the rat displays a low degree of insight which appears in certain situations in the maze but that for the most part his learning is 'stamped in.' *But it is inconceivable that two sets of principles, based upon logically opposite and incompatible assumptions, should be applicable to his behavior!* So much for a general comment on the laws of association. Detailed criticisms appear from time to time as the various conditions of learning are studied.

The Law of Configuration. The configurational view is presented in this text as a substitute for the association theory of learning. Evidence in favor of the configurational principle has already been noted at considerable length (pages 125, 245). To restate the principle, the organism is so constructed that any event of behavior, no matter how complex, is already an integrated performance the first time it takes

place, whether it be considered as a mental process or as an overt act. In the latter case, movements of various muscles are already associated as the act takes place. Association is subordinate, then, to the principle of *configurational response.* Specific mental processes and discrete movements are subordinate to the behavior of the organism-as-a-whole. Mental processes and movements alike exhibit an organization of their own the first time they take place. The entire problem should be borne in mind as we study more carefully the conditions under which insight, or organized response, develops in the learning process. Meanwhile we are left with the notion that maturation or growth is one of two main conditions and that the stimulus-pattern is the other (cf. page 311).

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CHAPTER X

LEARNING: THE MORE PRECISE FACTS AND METHODS

The Problem of Memory

Functions of the Time Interval between Observations. We have said that learning progresses with repeated observations of a given stimulus-situation and with repeated exercise with respect to a goal, but we have expressed the opinion that repetition of response or exercise, does not *explain* learning. However, the conditions under which a learner repeats his task are of paramount importance, for example, his attitude of mind, the insight which he brings to bear upon the task and the emotional character of the situation. Among these conditions is one of special significance, namely, *the time interval between repetitions.* It is a problem which opens two large fields of investigation: First, the subject's behavior during the time interval following *a single* observation and second, his behavior when conditioned by the time intervals *between* repeated observations and repeated performances of a given task. The outstanding functions or products of a single time interval following a single observation are *memory* and *forgetting.* The major function of intervals between repeated observations is a *growth* or maturation process, a *development which terminates in the emergence of NEW insight upon the next observation.* Following the time interval the learner constructs a *new and more elaborate* perception of the stimulus-pattern; he constructs a new perceptual configuration.

Definitions of Memory. A recent text defines memory as the capacity for reinstatement of a past impression or event in the absence of the original stimulus. In 1890, James defined it as knowledge of a former state of mind that had

meanwhile dropped from consciousness, or better, the knowledge of an event or fact of which meanwhile we have not been thinking, with the additional consciousness that we have experienced it before. Another recent definition makes memory a reinstatement of a past experience or a present awareness of a past experience, with the knowledge that it is familiar. There is a growing belief that these definitions are based on assumptions of only limited value. The first implies that a specific impression is made upon the nervous system at the time of the original observation. The second supposes this impression to remain as a trace, the persistence of which has been called *retention.* The third is the assumption of a trace brought to life by appropriate subsequent stimulation, a process which has been defined as *recall.* The fourth postulates a relationship between the recall and the original observation; the subject identifies his recall, that is, refers it to a past event, a procedure designated as *recognizing.* According to conventional definitions, therefore, memory involves four steps or stages, (1) impression or learning, (2) retention, (3) recall and (4) recognition.

No doubt there are certain practical reasons which justify the use of the terms retention and recall. After the individual has a certain experience, say a vacation trip, he can relate the events of that trip at a subsequent time. He has retained a knowledge about it and this retention of knowledge is a function of the time interval which has elapsed since the original experience. But as far as the facts of observation go, we know only that his behavior in 'recalling the experience' contains a logical *reference* to the past; in its meaning it relates to, or points to, experiences long since gone. If retention is employed to mean only that behavior at any time contains a specific reference to previous events, the term may have validity. Likewise, if recall means merely the act of making such a reference to the past, it may likewise have validity.

A Proposed Theory of Memory. The fact that a person experiences something in the past does not explain why or how he remembers that experience subsequently; neither does it guarantee that he will ever recall the experience; it is merely a sign that a particular set of conditions are function-

ing at that time. Whether in any given instance these conditions will persist in whole or in part remains to be ascertained by experiment. If they persist *in toto* and function at some later time the individual has another experience of a similar character; if they persist only in part the subsequent experience partially resembles the original. Therefore, recall is a response induced by certain of the stimuli that conditioned the original experience, and is a conception rendering the assumption of traces unnecessary.[1]

Consider a vacation trip to the mountains. Not only are the mountains and lakes features of the stimulus-pattern, but also the automobile, the camping equipment and the accompanying party. The stimulus-pattern also includes the behavior while on the trip and the words used at the time to describe the scenery. Later, on returning home, the numerous details of the complex stimulus-pattern, to which behavior while on the trip was a continuous response, have not all disappeared. Patterns, especially in the form of words and phrases partly resembling those which functioned during the trip, now give rise to responses that to a certain extent resemble the original reactions. These responses are not complete as compared with the originals and *the difference between the responses to the earlier situation and the response to the situation partly repeated is the difference between original observation (perception) and memory.*

This conception of memory portrays it not as the revival of a previous experience or in any strict sense of the term a recall of anything. Rather, it is an *effort on the part of the individual to experience a situation as he perceived it before.* This effort involves the use of visual, auditory, verbal and

[1] This account resembles to some extent Hollingworth's redintegrative theory. Cf. his *Psychology: Its Facts and Principles.* New York: Appleton, 1928, 257 ff.

The theory supposes, with Köhler, that there is always a particular organization of stresses within the nervous system which in part conditions the 'recall.' (Köhler, W., *Gestalt Psychology,* New York: Liveright, 1929, 272 ff and 311 ff.) These are the stresses which 'work over' the sensory stimulation. We can agree with Köhler, also, that the effect of a single stimulus in producing a 'recall' depends not upon a specific trace in the brain but upon the relationship of that stimulus to the organized pattern of brain stresses functioning at the time. Partly repeated stimuli elicit 'recalls' having their own organization which is not necessarily like the organization of the original observation.

other kinds of images. The objection may be raised that these images are reinstated sense perceptions. According to the present theory they are not reinstatements but are incomplete processes of perceiving; they are attempts to perceive objects which are not actually present. How then, when objects are not present, is it possible to reproduce them vividly in terms of imagery? It may be supposed that a memory of the object is constructed not from residues of previous impressions *but upon the basis of sensory stimulation occurring at the time of recall.*[2] *It is likely that the central nervous system amplifies and works over this sensory stimulation.* In the process of recall the individual supplies the missing stimulus-object.

To illustrate this principle by reference to another example, take the recitation of a poem from memory. Originally the learner had before him the printed page from which he read the words. He was then supplied with definite visual stimuli. When he recalls the poem, however, the printed page is lacking; in place of it he visualizes the page or follows the lead of his own voice as it silently speaks the words before he articulates them. In this way he furnishes himself with cues; he supplies the missing page. It is possible that the raw materials from which he constructs his visual imagery are nerve impulses that are constantly entering the brain from the retina. It is well known that in the absence of external stimulation, the retina contains 'inherent light,' an expression referring to the observation of brilliant flashes and schemata of color when pressure is exerted upon the eyeballs. These colors can be seen especially well when the subject is in the dark, and are noticeable at times even when no artificial pressure is used. It is a simple matter to observe the emergence of definite visual images from these retinal colors and to watch imagery shift and fade into them. The author has made these observations many times. To illustrate, in one instance and with no pressure upon the eyeballs, a series of white and greenish-blue streaks turned into a very clear image of an ocean scene. In another instance, a sofa with several brightly colored pillows faded gradually into splotches of yellow,

[2] Cf. The author's discussion of centrally aroused processes. *Amer. J. Psy.*, 1928, Vol. 40, 525–541.

green, blue and brown, just those colors that had figured prominently in the visual imagery. The most favorable conditions for noticing these phenomena seem to be a reclining position, absolute quiet and an attitude of permitting visual imagery *to come and go as it will.* Then the phenomena appear with no effort on the part of the observer. In fact many of the images come with no warning whatever. When the eyes are open in bright illumination, these colors are not observable but the retina is responding to external light. It is not impossible that some of the resulting energy from the retina, set in motion by the external light, is used in constructing visual imagery. In case there is no illumination of the retina, it is still functioning in the manner described.

If the observer recalls the poem or the vacation trip by means of verbal imagery the positing of brain traces is likewise superfluous. Words are learned in a variety of configurations so that, depending upon circumstances, certain words function as stimuli for a great variety of others, through proprioceptive channels. That is, thinking of words involves incipient movements of the speech muscles, and these movements furnish stimulation because the muscles are supplied with sense organs.

While it is supposed that the configurations are represented in the brain by systems of stresses there is no more reason for regarding these as traces than there is for the assumption of traces to explain physical growth. While brain configurations are constantly becoming more differentiated and complex as learning takes place, and are constantly functioning as the framework upon which subsequent maturation processes are based, it is misleading to construe them as traces. In growth, one cell is the basis of another, but not a trace of another. In chemical union, chemical elements are the basis of compounds but would hardly be interpreted as traces, although the elements find representation in the compounds. In case the learning process is fundamentally either a matter of growth or of the building up of chemical compounds, the process depends upon external influences and these influences, at the time of recall, are peripheral stimulations of the speech organs, of the retina or of other nerve endings of the body.

This evident dependence of recall upon peripheral stimulation means that the brain configurations really begin at the sense organ and terminate in the muscles. Now, words used in one connection are also used in others, just as the same hydrogen ions that exist in one compound will become aspects of another, following a process of chemical interaction. Accordingly, shift the stimulus-pattern and those brain processes responsible for a single word become members of different brain configurations. But the shifting depends upon external stimulation, not upon the revival of traces in the brain. And finally, the effect of particular stimuli depends upon the degree of differentiation of configurations within the nervous system, not upon conditions implied by the laws of association.

The Problem of Cues. It is customary to suppose that after repeating memorial material several times, say a poem, many of the cues disappear. How is this fact to be accounted for on the basis of the present theory? The explanation is this: *We do not use fewer cues.* In fact a greater number is used but they may have changed from the tangible, visual type, quite easily detected, to the verbal type which is very difficult to observe. The person who is reciting knows at each moment what words he is to articulate next; he anticipates them. Such knowledge consists, first, of verbal imagery so well formed that anticipating the words and actually saying them amount to the same thing. Second, knowledge of the words consists of an *attitude of certainty* assumed by the person who is reciting. In other words, cues are not processes set apart from recall but are integral parts of it. During the early stages of the learning process cues are fewer in number, more or less isolated from one another, and therefore more conspicuous. As the memorizing or learning progresses the cues change, become not only more numerous but also better organized, as a result of which they are less easily recognized. Finally, the act perfected, they lose their identity in the total, unified response. In this way the theory of memory that has just been presented takes cognizance of recognition.[2a]

[2a] In other words recognition disappears as the organization of the brain processes underlying perception becomes complete in any given

Origin and Development of the Concept of Memory Traces. Since the theory of memory traces has been questioned it would be pertinent briefly to consider its history, in order to understand more clearly how it became a psychological tradition. It was Plato who espoused the concept of memory traces, although he regarded it merely as an analogy; but his immediate followers accepted it as literal truth. Plato likened memory to a wax tablet on which impressions were made. If the wax was of good quality these traces persisted, for they were firmly imprinted in an enduring substance at the time of observation; but if the wax was of poor quality the traces soon faded. In this way Plato accounted for forgetting. To this day we still speak of 'sense-impressions' and the tradition has persisted that, when an observation is made, a trace is left somewhere within the nervous system. Centuries later Descartes spoke of traces as pores in the brain, widened by the passage of 'animal spirits' (nerve impulses) through them after the latter had been stirred to action by stimulation of the sense organs. In this way he endeavored to explain habit formation. William James followed the same tradition when he interpreted habit formation as the wearing of pathways through the brain. Still more recently a famous British physiologist, Sherrington, emphasized the *synapse* as the place within the nervous system at which such changes occur as will account for the acquisition of new muscular co-ordinations. A synapse is a point of juncture between two nerve cells (structural units of the nervous system) where there are two membranes, one at the end of one

instance. A specific process of recognizing takes place when the stimulus-pattern requires a *reorganization* of brain processes. To illustrate, suppose a person starts to open a door and the knob will not turn. Up to this time he has not explicitly recognized the knob; he has merely perceived it. The knob sticks, however. For an instant perceptual processes are held up; tension arises; an immediate goal is established, expressible in the words, 'Is this the knob?' or, 'What is the matter with the knob?' The main feature of the recognition process then appears as a sudden resolution of the tension, and an important aspect of this resolution is the experience which the person describes as a 'feeling of familiarity.' (Expressible in the words, 'Yes, this is the knob.') Accordingly, the feeling of familiarity, which is so often the prominent feature of a recognition process, is not associated with a simplification or mechanization of brain activities but with a reorganization of them into more complex and highly organized configurations.

cell and the other at the beginning of the neighboring cell. These membranes offer resistance to the passage of nerve currents, but this resistance supposedly lessens as nerve currents continue to pass through the synapse. Thus, 'impression' or 'trace' became a 'lessened resistance at the synapse.' Pillsbury, Thorndike and others accepted the synapse theory as a physiological explanation of memory, habit and learning.

Köhler's Theory of Traces. One of the latest theories of traces comes from the *Gestalt* or configurational literature. Köhler [8] suggests, first, that when an external stimulus impinges upon the nervous system, the existing state of the system changes until it is in equilibrium with the force that is acting upon the sense organ. Let another stimulus affect another part of the nervous system and the first approach to an equilibrium will be altered by the change going on toward equilibrium with the second stimulus, and *vice versa.* In this way the responses to the two stimuli are interdependent and the final outcome depends upon the dynamic relation between the two levels of equilibrium. Second, it is supposed that the approach to equilibrium which commences upon stimulation so alters the concentration of reacting substances in the brain that a process of adjustment must continue after the stimulus is removed. This process of adjustment may determine for a considerable time the direction of changes elicited by subsequent stimuli. But remember, this is after the 'conscious' process associated with the first stimulus has disappeared; accordingly, the continuing brain process is called a 'non-process condition,' because it is not associated with conscious processes. The 'non-process condition' is Köhler's substitute for the older concept of trace.

Unlike the former notion of a static, stable trace, the 'non-process' phenomenon is dynamic and constantly changing, since it influences adjustments to subsequent stimuli and is influenced by them. Suppose that an old 'non-process' trace, which may be construed as a given system of brain stresses, comes in contact with a new trace. Then the two affect one another in a way that may result in a *new mental process.*

[8] Köhler, W., "Zur Theorie des Sukzessivvergleichs und der Zeitfehler." *Psy. Forsch.* 1923, Vol. 4, 115–175.

Thus, errors of memory and the creations of imagination are given a general physiological explanation.[4]

Wulf's Experiment and Its Bearing Upon 'Traces.' Wulf [5] obtained experimental results bearing upon this problem. He showed several observers a variety of simple, geometrical figures and asked them to reproduce them from memory immediately after presentation, again twenty-four hours afterward, then at the end of a week, in some instances at the end of a month and longer. He obtained curious results. In many of the successive drawings there was a constant and progressive change either toward a reduction or an exaggeration of the figure. For example, a broken line became either a straight one or an angle. But more significant was the fact that the change was generally toward a balanced or symmetrical figure. It may be conjectured, therefore, that the traces or systems of stresses were undergoing changes in shape toward more stable patterns, and that these changes produced the constant variations in the drawings. It may be added that the more stable configurations of physical stresses are balanced or symmetrical in accordance with the conditions of least action. (Other things being equal, drops of water are round, the human body is relatively symmetrical, the earth is round, planetary orbits are ellipses, simple waves are symmetrical, crystals assume symmetrical shapes, and it is probable that molecules have symmetrical patterns.) It would not be surprising if according to the same principle the patterns of energy in the neuromuscular system approach a symmetry of one or another kind if, when first formed by the stimulus-pattern, they are irregular. If so, it is likely that Wulf's subjects were inclined to make balanced figures in accordance with the conditions that produce least action.

A Comment on the 'Non-Process' Theory of Traces. The theory of traces which we have just been discussing contains one or two features which may require modification. *First,* it is doubtful whether according to the conditions for

[4] Cf. Koffka, K. "On the Structure of the Unconscious," in *The Unconscious, A Symposium.* New York: Knopf, 1928, 43–68.

[5] Wulf, F., and Koffka, K. "Ueber die Veränderung von Vorstellungen (Gedächtnis und Gestalt)." *Psy. Forsch.* 1922, Vol. 1, 333–373. Quoted by Koffka, *loc. cit.,* 56.

least action which the theory implies, there can be an isolated or purely local effect in the nervous system. The brain is never free from external stimulation, even in sleep or when the organism is under a general anaesthetic. There are many reasons which make it almost necessary to suppose that energy patterns involve the entire neuromuscular system. They extend from sense organs through the brain and spinal cord to the muscles and hence back to sense organs again, for the muscles are supplied with sense organs[6] (see page 432). To put it differently, the state of the sense organs and muscles (all of which are continuously functioning) is a factor to be reckoned with in nerve integration, since the potentials at these points must of necessity be influencing stresses within the brain.

Second, if any given energy pattern always involves a complete circuit from sense organ to muscle, such effects as Köhler attributes to traces may be interpreted more simply in terms of the law which he implies. Returning to Wulf's experiment for an illustration, it may be supposed that in accordance with the circumstances of least action his observers favored balanced or symmetrical figures. With other conditioning factors reduced to a minimum, such as purpose in mind and external stimuli, it is easier to see symmetrical than irregular figures, and it is easier to draw them. In other words, the fact alone that the visual apparatus and brain-hand mechanisms taken together would be functioning in the line of least action, would account for the inclination of Wulf's subjects to change their figures. Results analogous to Wulf's may be obtained by commencing a figure and asking a subject to complete it before he has time to think about what he is doing. He will make a symmetrical more often than an irregular pattern. Moreover, the preponderance of symmetry or balance in painting, design, pottery and even in the drawings of primitive people and children, is consistent with this view. Likewise, symmetrical figures are the easier to perceive under brief exposure. It would be strange if the retina

[6] Wheeler, R. H., "A Theory of Circuit Integration: A Criticism of the 'Centrally Aroused Process.'" *Amer. J. Psy.* 1928, Vol. 40, 525–541.

and the muscles of the eye and arm had nothing to do with the setting up of those symmetrical patterns of energy within the nervous system that correspond to the drawing!

Third, in the case of Wulf's subjects there were obviously many verbal and gestural stimuli which served to touch off recollections. These stimuli included the formal instructions to the observer, together with self-instructions. Moreover, the observers undoubtedly remembered the figures partly by means of language and these language stimuli alone might have led them to construct, not to reproduce, figures that in some way resembled the originals and could be recognized as familiar. Couple this possibility with the conditions for least action and a theory of traces is superfluous because the state of the neuromuscular system at any time, together with a complication of muscular and visual stimuli, make possible the product which Köhler attributes to traces.

Crosland's Study of Memory and Forgetting. The view that recall is a matter of making observations in the absence of completely repeated stimulus-patterns receives substantiation from Crosland's [7] study of memory and forgetting. Crosland's method was extremely simple; he briefly exposed different objects to his observers, such as a mannikin, colored and uncolored pictures and geometrical designs. Immediately after the presentations the observers told all they could about the objects and described in detail the mental processes to which they could reduce their recalls. Then they made subsequent recalls after longer and longer lapses of time and described their experiences as before.

Among other things Crosland found that his observers assumed definite attitudes toward the exposed objects during the original presentations, and retained these attitudes during subsequent recalls. Moreover, they resisted forgetting; in each recall they were trying to inspect the object as if it were actually present. As time went on their memory became more and more subject to error and these errors were determined in large measure by the effort to resist forgetting. Crosland

[7] Crosland, H. R., "A Qualitative Analysis of the Process of Forgetting." *Psy. Mon.* 1921, Vol. 29, No. 130.

interpreted this situation in a manner somewhat different from the conventional view of forgetting which made the latter a passive process.

We shall proceed a step farther and interpret forgetting not only as an active process on the part of the observer but as an effort to continue learning under adverse conditions. Indeed, forgetting in general is a learning process taking place in the absence of completely repeated stimulus-patterns, and the proverbial errors of memory are based on inadequate control. The observer's attitudes toward the object, his desire to recall as much as possible, his concept of what the object should be, his desire for the object to take on certain characteristics, are uncontrolled in the absence of the object. This conception of forgetting is substantiated by the fact that each time an actual object is re-observed the perception of it becomes more and more comprehensive and accurate. Likewise, with each recall of an absent object, there is an inclination to construct more and more details concerning it. Forgetting is not something different from learning, therefore; rather, it is the same process taking place under a practical handicap.

Errors of 'Recall.' The results of Crosland and others show that the resistance to forgetting reveals itself in numerous ways. First, there is of course the obvious *error of omission* to which every recall is subject. Since the actual object is not present the observation is incomplete, but an incomplete observation is possible since the actual object is only a part of the original situation to which one responded; other stimuli belonging to that situation are repeated (see page 271). *Second,* attempts to overcome errors of omission result in errors of commission or elaboration. The conditions under which these errors appear are numerous, including social conditions; we have already anticipated some of them. (1) The narrator is eager to give an elaborate account either for the sake of boasting or for the sake of telling a good story; hence he unwittingly adds features to the object which it never possessed. (2) A person's memory is always subject to alterations through influences from other individuals; these alterations change the relationships of the facts recalled and distort the recallers' memory of them. Some one doubts the recaller's

veracity and attempts to correct him. Moreover, there may be a particular feature of his recall the importance of which had not been realized before it was brought to his attention. (3) The narrator emphasizes and elaborates the facts that harmonize best with the emotional tone engendered in the social situation at the time of recall. (4) The narrator is inclined as time goes on to recall past events as he thinks they should have taken place.

Third, resistance to forgetting assumes the form of typifying the object or event recalled. The narrator makes the object conform to the average of the class to which it belongs. For example, a friend of the author who had graduated from a college at Baldwin returned to the campus years afterward only to discover that a hill which he was fond of climbing had disappeared. In the meantime he had lived for several years among high mountains on the Pacific Coast. His memory of the Baldwin hill had suffered because his concept of these objects had changed; his average hill had greatly increased in height; accordingly he had enlarged his image of the one at Baldwin until the real hill in contrast seemed nothing more than an inconspicuous rise in the contour of the landscape. Thus as time elapses, a memory of a simple event may become general enough to represent a number of previous experiences.

Fourth, because of their homogeneity, verbal and motor experiences are subject to relatively fewer errors of recall than the visual or other experiences that depend upon the more specialized senses. The visual aspects of objects, their color, outline, size and spatial relations, are soon forgotten unless language (verbal imagery) can be relied upon to supplement visual imagery. The features of events that can be symbolized easily in single words and gestures are recollected with greater accuracy. In fact, as remembrances fade, words and gestures dominate as tools of recall until finally all that remains is a motor attitude. To illustrate, a young boy suffered from eating too much blueberry pie and remembered the details of the incident for some time. After a period of twenty-five years there remains, out of the original experience, only a dislike for the pie. As a consequence when

someone asks, Will you have some blueberry pie? he shrugs his shoulders and replies, *No,* thank you.

The Psychology of Testimony. An outstanding achievement of modern psychology is its contribution to the problem of testimony. The practical results of this work are presented in the following summary: *first,* testimony is ordinarily based upon only one observation of an event. Moreover, the observation is not made with the intent to remember, and being incidental it is inevitably superficial. The more pertinent features of the incident may not have been noticed, for what the observer saw and heard depended upon his attitude and interest at the time. Meanwhile there has been no repetition of the event by means of which to complete and verify the observation, or to prevent the distorting influences of prejudices and opinions.

Second, incidents leading to court procedure almost invariably arouse feelings and emotions; they are incidents of an exciting nature associated with fear, anger and sorrow, or they may arouse disgust, humiliation and curiosity. These conditions lead the observer to sympathize either with the plaintiff or the defendant whereupon he is no longer an impartial witness.

Third, testimony is seldom taken immediately after the incident; frequently weeks or months have elapsed. In the meantime the numerous errors of elaboration and deletion to which remembrances are subject render testimony extremely unreliable.

Fourth, the circumstances under which testimony is given are unfavorable to recall. The witness may be frightened or embarrassed; he may be subjected to intimidating and leading questions. Moreover, the witness generally gives his testimony for a particular purpose and questions are directed to him by individuals whose object is to prove a point. A clever cross-examiner can distort almost any testimony by pointing out apparent inconsistencies and by suggesting wrong emphases.

Fifth, the trouble-maker who must testify in self defense is frequently unscrupulous; he is naturally a biased observer of facts and always possesses a powerful motive for distort-

ing them even should he attempt to be honest in his testimony.

Sixth, the testimony of any witness of inferior intelligence, immature age or psychopathic disposition, is almost wholly untrustworthy. A person of this type is highly suggestible, he is imaginative and he comprehends imperfectly not only the nature of the questions addressed to him but also his own testimony.

Seventh, testimony deals with facts that are subject to gossip. The witness has probably discussed them so often that they have become unduly vivid and real.

Cases of Long Latent Memory. Forgetting is often a serious problem; nevertheless, evidence from many sources proves that under exceptional circumstances we have forgotten much less than we would have believed. Individuals who have been on the verge of drowning relate how experiences scattered over years of time came to them vividly as they realized they were about to die. Warren [8] has reported a different and more striking type of case. An elderly man returned to his Alma Mater to receive an honorary degree. Amid certain of the festivities of this occasion he excitedly arose and recalled *verbatim* the text of his freshman oration! In delirium a person may recite stories of events long since forgotten during normal, waking life. So too, under hypnosis, it is possible to induce experiences that are beyond the limits of voluntary recall. Morton Prince tells of a patient who recalled under hynopsis some passages from a newspaper, which he could not remember under ordinary conditions, although he could recollect material from other columns on the same page. In fact he insisted that he had not read the columns from which he had quoted.

Years ago Coleridge told of a servant girl who, in a delirium, recited a jargon which none of her associates could understand. A physician who attended her recognized the languages she was speaking as Greek and Hebrew, and set about to find the source of her apparent language facility, which seemed remarkable because she had studied neither

[8] Warren, H. C., "Two Cases of Long Latent Memory." *Psy. Bull.* 1918, Vol. 15, 207–209.

Greek nor Hebrew. It happened that several years previous to this incident she had worked for a clergyman whose habit it was to pace his study, reciting aloud long passages from Greek and Hebrew books. The physician was able to locate in certain of these books the passages which the girl had quoted in her delirium. Evidently she had listened to the clergyman without understanding what he was saying, yet later she was able to reproduce certain of the passages. Such cases as these are evidently to be explained on the basis of a greatly increased sensitivity which is often present in hypnosis (see page 63) and hysteria. Both Prince's patient and the Coleridge case were hysterical individuals. They responded to visual and auditory stimuli which are ordinarily imperceptible to normal individuals, and proceeded immediately to forget them. Performances of a similar nature may be found in the utterances of *bona fide* trance-mediums and in automatic writing.

Amnesia and Related Phenomena. Related to latent memory are various phenomena of amnesia. Amnesia, or loss of memory, is an abnormally limited mode of behavior associated on the one hand with physical injury (generally of the head) and on the other, with hysteria. The amnesia following physical shock is ordinarily partial and temporary. Since it involves a loss of memory for events immediately prior to the shock it has been characterized as *retroactive* amnesia. A victim of an airplane crash may be unable to remember how the accident happened or that he had been flying at the time; likewise, persons injured in train and automobile wrecks occasionally report a complete inability to remember events occurring during a period of several minutes to several hours prior to the accident. There is no definite evidence by means of which to explain this type of amnesia. The hypothesis has been offered that there are newly formed nerve patterns corresponding to the experiences previous to and including the accident. Before these patterns will subsequently function they must be incorporated into the brain organization as a whole. In turn the incorporation involves a maturation of the new patterns, which is prevented by the

injury, hence the experiences lack representation in the nervous system and can not be recalled.

The following is a case of hysterical amnesia which came to the author's attention during the late war. A young recruit from the draft showed at the outset that he was afraid of war. Because of his attempts to avoid drill and other military duties his commanding officer became extremely harsh with him, which only aggravated matters. One day the boy was walking toward the mess-hall and forgot not only where he was going but who he was. He wandered aimlessly about the camp and finally entered a Y. M. C. A. hut where he returned to normal. Not many days afterward he suffered another attack; this time he escaped from the camp and reached the railroad station where he bought a ticket home. The amnesic period ended while he was on the train. He was unable to explain his presence there, and fearing the consequences of returning to camp he finished his journey. Shortly afterward, federal officers arrested him for desertion; and at the courtmartial he could not give a satisfactory account of himself.

The conditions that limit behavior of this sort are the same as were studied under suggestion and emotive behavior. *First,* the individual possesses a nervous system of low resistance caused by prolonged emotional strain. As a consequence, tensions reach a high degree of intensity and demand relief or compensation proportionately. *Second,* with low resistance to tension-producing situations the individual is less able to find normal avenues of outlet; his behavior is claimed by exaggerated wants which prevent him from developing a normal insight into his condition. The boy in the illustration feared going to war; he could see none of the incentives which led his comrades either to throw themselves wholeheartedly into military service or to submit to the situation in a matter of fact way. Accordingly, his intense and persistent craving to free himself from the intolerable demanded termination some other way. It came in the line of least action, in the most direct way under the circumstances; he could not alter his environment, therefore he altered himself. The wish

led to its own fulfillment just as all tensions are resolved toward equilibrium; he forgot who he was. He partially disintegrated his personality, not through deliberate effort but through the energy of his craving. Fundamental goal-activities survived; when he was hungry during an amnesic period he would eat; he would converse but confessed an ignorance of all things relating to the intolerable situation; he had not forgotten his home and wanted to return.

The question arises, why did he recover from his amnesic periods? The amnesia gave him temporary relief from tension; it was escape from the aggravating environment. But it may be supposed that during the amnesic period a gradual recovery process took place until there was a return to normal. Then the disintegration repeated itself when he again confronted the environment that was producing the tension. This explanation also covers phenomena like day-dreams and absent-minded periods which are similarly induced in normal behavior. Trances and somnambulistic performances which are exaggerated forms of day-dreaming can be explained in like manner.

The recruit in the illustration just cited advanced only through the first stages of hysterical amnesia. In other cases the disintegration process and recovery repeat themselves. In these repeated periods the conditions of the malady remain relatively the same, hence the patient remembers from one to another but recalls nothing from his normal life. Moreover, within these periods maturation processes continue until the individual develops a *second personality* which knows nothing of the first, hence the state known as *multiple personality.*

Cures of these amnesias, trances and divided personalities are effected in proportion to the patient's ability to develop insight into the situations which arouse tensions; that is to say, improvement depends upon a change of goal. This change is accomplished usually with the help of a psychiatrist but occasionally by the patient himself after an exciting emotional experience. For an example of the former see page 180. An illustration of the latter is found in the hysterically lame man who was frightened into running normally by an

escaping horse that dashed in his direction. After discovering that he could co-ordinate his muscles he could walk, but it required an emotional shock to give him the necessary goal.

The older psychology attempted to explain all of the phenomena of hysteria such as amnesia, trances, anaesthesias, somnambulism and multiple personality as dissociations of consciousness. Since then dissociation has been accepted as a descriptive rather than explanatory term, and many investigators are inclined to avoid using the term dissociation altogether. The Freudian approach and especially Kempf's recent conception (page 195) are more adequate; both can be subsumed under the general law of least action.

Measurements of Forgetting. Forgetting was first measured in the laboratory by Ebbinghaus, in 1885, who worked with meaningless (nonsense syllables) and meaningful material. He constructed several series of nonsense syllables, twelve in a series, a single syllable written upon a card. Then he exposed a series to himself at a fairly rapid rate, allowing fifteen seconds at the end of the series before he re-exposed it. Successive readings were continued until he was able to recite all twelve syllables correctly. At the end of nineteen minutes he relearned the series, recording the number of 'repetitions' necessary for perfect recitation. He called this the *saving method* because the number of repetitions saved in the second experiment compared with the original learning was a measure of 'retention.' Then he selected another series and after learning it in a similar fashion, relearned it at the end of sixty-five minutes. As before he recorded the amount of saving. He relearned a third series at the end of eight hours, a fourth at the end of twenty-four hours, a fifth after two days, a sixth after six days and a seventh after thirty days. He plotted the percentage of saving in each instance and obtained his famous curve of forgetting which is reproduced in Figure 27. Under the conditions of this experiment, forgetting proceeded very rapidly during the first twenty minutes. More than one half of the material was forgotten during the first hour. Then the rate of forgetting rapidly decreased. Many investigators have repeated Ebbinghaus' experiment with approximately the same results when nonsense

syllables were used, but his curve holds only for meaningless material.

Other Methods of Measuring 'Retention.' Following Ebbinghaus' original investigation which lasted over the period of years from 1879 to 1884 [9] a voluminous literature on memory appeared, all based upon modifications of the methods and problems which he introduced. We can summarize only a few of these methods, most of which employ nonsense syllables.

1. *The method of retained members.* Material is presented the subject until he has it almost learned, to avoid the danger of

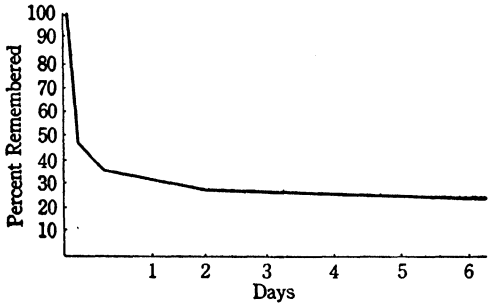


FIG. 27. CURVE OF FORGETTING (Ebbinghaus).

varying amounts of overlearning in different subjects. Retention is measured by the number of items correctly remembered after a stated interval of time.

2. *Method of right associates.* (Scoring method.) Syllables or words are presented in pairs. At a subsequent time the first unit of each pair is presented. Retention is measured by the percentage of correct associates. This procedure makes a study of 'false' responses possible, and measures the strength of individual 'associations.'

3. *Method of complete mastery.* Series of syllables or words are repeated until the subject can recite them all correctly. Retention is measured by the number of repetitions or by the amount of time required in the original learning.

4. *Saving method.* A series is learned to complete mastery, then at a subsequent time it is relearned. The retention is measured by the number of repetitions (or time) saved in the relearning.

[9] *Op. cit.*

5. *The memory span method.* Series of gradually increasing length are each presented only once. Retention is measured by the number of units in the longest series which can be correctly reproduced immediately after the presentation.[10]

Influence of Amount to be Learned on the Rate of Learning. An example of the many specialized studies of memory and forgetting is found in an investigation by Robin-

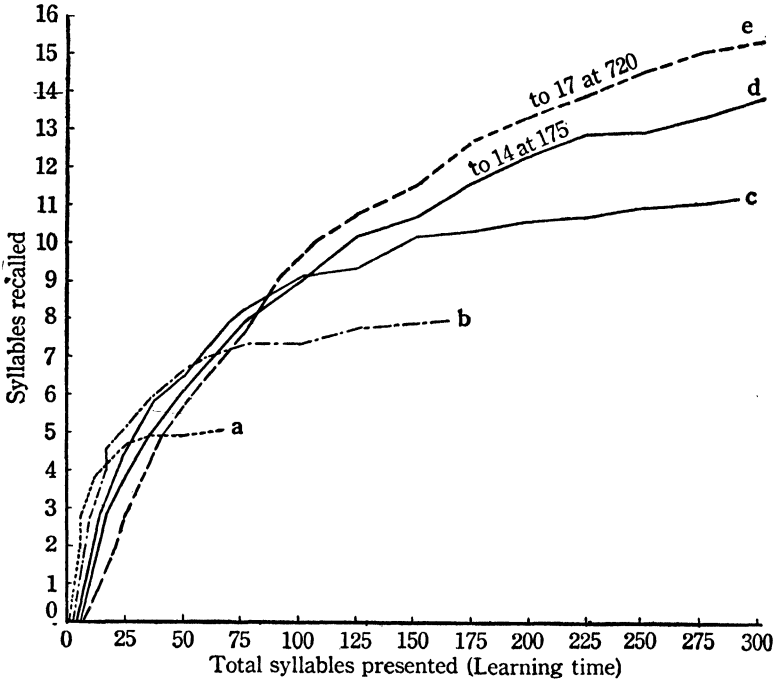


FIG. 28. CURVES SHOWING THE INFLUENCE OF AMOUNT TO BE LEARNED ON THE RATE OF LEARNING (Robinson and Heron).

son and Heron,[11] the influence on learning of the amount of material to be learned. Ten subjects were presented lists of 6, 9, 12, 15 and 18 nonsense syllables. The anticipation method was used; that is, after the first syllable appeared, the subject attempted to anticipate the next syllable in the

[10] Cf. Foster, Wm. S., *Experiments in Psychology.* New York: Henry Holt, 1923, 242 ff.

[11] "Results of Variations in Length of Memorized Material." *J. of Exp. Psy.*, 1922, Vol. 5, 428–448.

list. He repeated this process until he was able correctly to anticipate each syllable before it was exposed, counting the first one as a cue. Figure 28 shows the learning curves for series of different lengths when the total number of syllables presented was taken as representative of learning time and plotted against the number of syllables recalled. Notice that by the time twenty-five syllables had been presented, in the six syllable list, the observers were able *on the average* to anticipate five syllables correctly, a perfect score under the conditions of the experiment. A perfect score in recalling the nine syllable list was not attained until there had been a total of over one hundred syllables exposed.

The following results were obtained: (1) The shorter the material the more rapidly learning takes place in its earlier stages and the sooner a stage of relatively slow progress is reached; the more material there is to be learned the slower will be the progress in the first part of the learning. (2) The number of repetitions required for complete learning increases rapidly with the first few increases in length of material; in other words, with subsequent extensions in length the number of repetitions increases more slowly. (3) Shorter lists are more rapidly forgotten than longer lists.

The Problem of Repetition *versus* Maturation

The Problem of Repetition. The belief has been popular that retention is proportional to the number of times the memorial material has been studied and that repetitions employed after complete mastery are efficacious in producing highly accurate recalls after long lapses of time. Under the conditions of experimentation these facts seem to have been verified; nevertheless, recall is not alone a function of repetition of response. Indeed, it is a question whether repetition should be construed as a causal factor in the learning process. At least there are numerous other factors, not under control in experiments on the effect of repetition, that greatly reduce the correlation between repetition and the amount learned and retained. A given number of repetitions varies in its so-called effect upon different learners because

the same material is more meaningful for some observers than for others. Spacing of work and rest periods is another important factor that reduces the correlation. Moreover, in many forms of behavior large numbers of repetitions are associated with opposite effects from those expected according to the law of frequency. The tannery worker ignores the foul odors of his environment and the machinist does not notice the din of the machine shop. On the other hand a person will instantly respond to other frequently repeated stimuli such as his name and the ringing of the telephone. If repetition of response is a dynamic factor one would not suppose the correlation to be positive in some instances and negative in others. Let us examine the facts of experiment.

Peterson's Test of Frequency and Recency as Factors in Learning. In 1922, Peterson gave the repetition theory of learning a rigid test.[12] He employed 20 subjects who learned to trace an imaginary maze in which there were a great many blind alleys. The procedure was so arranged that *repetitions of stimuli* were equally balanced for and against learning; at stated periods in the learning the subject had an equal chance of choosing the right or wrong path at a V-shaped juncture. His subjects learned the problem, some with striking rapidity. According to the recency and frequency theory repetition of response would have hindered the learning process under the conditions prescribed by Peterson. Indeed, recency and frequency factors should have produced chances that were 1024 to 1 against learning. Yet it took place in spite of the *effects both of recency and of frequency of response.*

Distribution of Repetitions as a Condition of Learning. It has already been intimated that *the distribution of work and rest periods* is a major condition of learning. The importance of this factor for the learning process became apparent as early as 1897, when Jost[13] published results from extended studies with nonsense material. He found that "when two associations are of like strength but of unequal

[12] Peterson, J., "Learning when Recency and Frequency Factors are Negative." *J. Exper. Psy.*, Vol. 5, 1922, 270–300.

[13] Jost, A., Die Assoziationsfestigkeit in ihre Abhängigkeit von der Verteilung der Wiederholungen." *Zeit. f. Psy.*, 1897, Vol. 14, 436–472.

age, repetition increases the strength of the older more than of the younger association." This is known as *Jost's law.* It means that if A was associated with B a month ago and C was learned in connection with D yesterday, other things being equal A is more effective today in suggesting B than C in suggesting D. In other words, a time interval increases im-

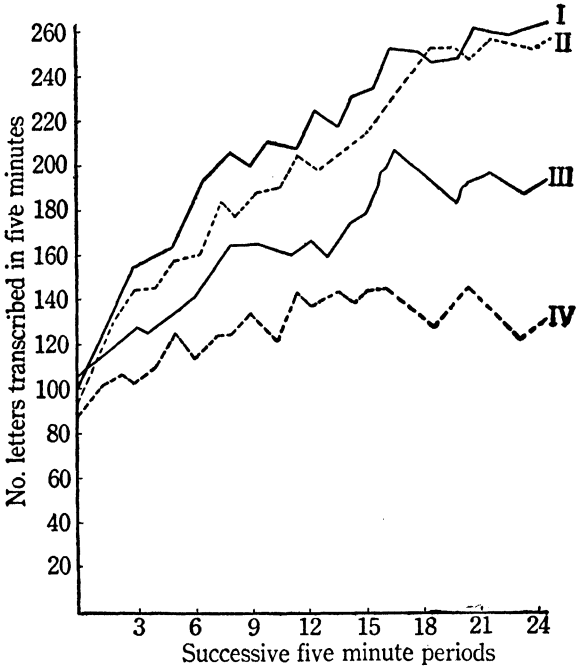


FIG. 29. CURVES SHOWING THE VALUE OF SPACED REPETITIONS (Starch).

Curve I shows the performance of the 10-minute group; curve II shows the performance of the 20-minute group; III is the performance of a group that worked for two one-hour periods, and IV is the showing made by the group that worked steadily for two successive hours. All groups spent the same amount of time on the task.

portance of subsequent presentations of material previously exposed.

In 1912, Starch[14] studied the effect of various distributions of 120 minutes of practice time. The task was to substitute numbers for letters according to a certain key. When

[14] Starch, D., "Periods of Work in Learning." *J. Educ. Psy.*, 1912, Vol. 3, 209–213.

successive five-minute periods were plotted against the number of letters transcribed during that time, his results took the form of the curves shown in Figure 29. The most rapid progress and by far the greatest total gain were made by a group of subjects working 10 minutes twice a day for 6 days. A group working for a 20-minute period each day for six days did less well; a group working continuously at the task for 120 minutes made the poorest record.

An interesting study was made by Perkins[15] in 1914 who measured the effectiveness of 16 repetitions of nonsense lists divided into periods of 1, 2, 4 and 8 readings, with 1, 2, 3 and 4-day intervals for each period-length, thus making 16 different distributions of the learning. She selected as her measure of learning the percentage of syllables correctly recalled after a two-week interval. The following table shows her results:

TABLE VIII

RELATION OF RECESS-PERIODS TO LEARNING

	Day Interval			
	1	2	3	4
	Per cent	Per cent	Per cent	Per cent
1 reading of list	79	72	82	68
2 readings of list	43	78	65	45
4 readings	25	33	29	41
8 readings	9	16	11	17

With one reading of a list each day until sixteen readings had been made, there was a recall after a two-week period of 79 per cent of the syllables. With two readings of the list a day for eight days the retention was only 43 per cent. With four readings a day for four days the percentage remembered was only twenty-five and for eight readings a day for two days only nine per cent of the syllables were remembered. The advantage of spaced repetitions held almost universally for the other distributions of day-intervals. If one studies the table carefully he will notice that as the number of readings per day increases, the longer should be the time interval between work periods. In this particular experi-

[15] Perkins, N. L., "The Value of Distributed Repetitions in Rote Learning." *Brit. J. Psy.*, 1914, Vol. 7, 253–261.

ment varying the length of the practice period had a more profound effect upon the recall than varying the interval between practices.

Snoddy's Study of Mirror Drawing: Irradiation. In a study of mirror tracing, in 1920, Snoddy [16] discovered some of the reasons why bunched or *series-practice* is less efficacious than distributed or *recess-practice*. He used a star-pattern which his subjects traced in mirror vision, a situation which compelled them to move their stylus in the opposite direction from that which first appeared to be correct. He found that spaced repetitions were necessary in the earlier part of the learning. Not until movements had been well co-ordinated, with the attainment of considerable speed, was series-practice effective.

Introspections from his subjects showed that in series-practice, early in the learning, there was a marked change of attitude from that of caution and accuracy to carelessness and speed. Snoddy regarded this change as inevitable for the reason that as the repetitions accumulated the subjects brought into play more and more arm-musculature; they became tense and lost their co-ordination. Snoddy described this as an *irradiation pattern*. The pattern not only revealed itself in a spreading of muscular tensions but also in the observer's manner of perceiving the star. With recess-practice and a slow, deliberate procedure the subject concentrated his gaze upon a region near the end of the stylus; with increased practice and improved co-ordination he enlarged the area which he embraced at a single glance, a change which took place slowly. With series-practice the case was quite different. The scope of a single glance increased very rapidly but the viewing was superficial; the learner was unable to judge the corners and sides with any degree of accuracy. The reverse was true when, with recess-practice, his judgments increased in accuracy as they increased in complexity.

Everyday Observations Bearing on Snoddy's Results. Irradiation patterns occur in much the same way during at-

[16] Snoddy, G. S., "An Experimental Analysis of a Case of Trial and Error Learning in the Human Subject." *Psy. Mon.*, 1920, Vol. 20, No. 124.

tempts to write a long letter. A person may commence with the firm intention to write legibly throughout; the first page looks pretty well, the third is not quite so good, the fifth is somewhat of a scrawl and the seventh is barely readable! Meanwhile he becomes more and more tense, and near the end he is suffering a writer's cramp. The same phenomenon appears in prolonged periods of study. After the student works unsuccessfully for an hour on a problem in mathematics, for example, he is less efficient toward the end than he was at the beginning. His 'mind turns a blank'; this 'blankness' corresponds to the muscular tenseness produced by repetition of the same movements over and over without rest. It is a symptom of irradiation; it is more than mere fatigue; it is a disintegration of nerve patterns. Introduce a recess-period, go to bed, attack the mathematics problem in the morning and the solution is easy, not as was formerly thought because the student solved the problem during his sleep through unconscious cerebration, but because he has recovered from the disintegrating effect of repetition.

We see that the interval between work periods and the length of the work period are more important factors than sheer repetition. However, we almost constantly proceed as if the opposite were true. *In our educational system the effect of drill, formerly thought to be the outstanding factor in learning, is to sterilize the insight of the learner and to kill his interest in the task by the creation of irradiation patterns.* Nervous breakdowns, in fact, are illustrations of irradiation on a large scale, brought about by excessive work and prolonged emotional stress.

The Plateau in Relation to Irradiation. An interesting result was obtained in one of the earliest studies of the learning process made by Bryan and Harter in 1897.[17] They measured the rate of learning to send and receive the telegraph language, plotting the number of letters decoded per minute against number of weeks' practice. In one subject, progress continued at a fairly uniform rate for the first sixteen weeks, with the same amount of practice each day. Then for about

[17] "Studies in the Physiology and Psychology of the Telegraph Language." *Psy. Rev.*, 1897, Vol. 4, 27. Also Vol. 6, 1899, 346.

eight weeks progress ceased almost entirely, only to begin again at the end of that time. In another subject there were two periods during which there was no visible progress. These stationary periods or *plateaus* attracted a great deal of attention and engendered a prolonged controversy as to their cause.

For a number of years the plateau was regarded as something inherent in the learning process and numerous theories were advanced to account for it. Among them were: (1) The learning process consists of acquiring a heirarchy of habits. In receiving the Morse code, for example, letters must be learned first, then methods must be found by means of which the sounds can be re-perceived not as individual dots and dashes but as organized patterns that represent whole words. After facility in receiving words has reached its maximum another change in method is required in order to combine words into phrases. Plateaus appear while the learner is acquiring a simple order of habits sufficiently to permit their organization into a higher order. Further experimentation in telegraphy and in other performances such as learning a foreign language, typing and shorthand, failed to substantiate this theory. (2) A plateau indicates a decline of interest. This theory proved inadequate when evidence was brought forward showing that plateaus appeared while the subjects were concentrating their best upon the task. (3) After the learner has made too rapid a progress he must moderate his speed to permit an assimilation of the material already covered. The general lack of correlation between plateaus and amount learned seemed to invalidate this theory. The fact that plateaus did not always appear in the same type of performance, and the fact that they occurred anywhere along the learning curve indicated their dependence upon the conditions under which the material was presented. Finally, *Snoddy showed that plateaus could be controlled by the distribution of work and rest periods.* Series-practice too early in the course of the learning always cause a period of no progress and generally a loss. Plateaus therefore result from faulty distributions of stimulation; they are caused by irradiation patterns. Lack of interest and monotony prove to be qualitative symptoms of irradiation, not causes.

Bird's Study of Maturation versus Repetition in Learning. Additional doubt has been cast upon the value of sheer repetition in learning by Bird[18] in his experiments on pecking in chicks. Large numbers of chicks were hatched in absolute darkness and confined there until they were taken out for purposes of experimentation. One group was removed shortly after hatching and their accuracy of pecking was very carefully controlled and measured; another group was selected at the end of 24 hours when similar observations were made; still other groups were used at the end of 36 and 48 hours. In the meantime none of the chicks had practiced pecking, for they will not peck in the dark, although they are hungry. In general, within the limits of the experiment, the older the chicks the more accurate their pecking movements, hence a curve was obtained resembling a learning curve. This could not have been a practice curve but on the contrary a result of *maturation* (see Figure 30).

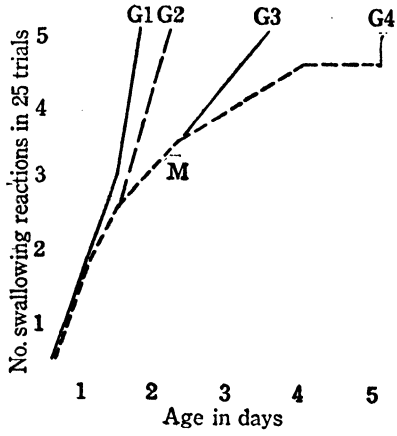


FIG. 30. CURVE OF 'MATURATION' IN YOUNG CHICKS (Bird).

The curve of 'maturation' (M) was obtained by connecting the beginning points of the learning curves of four groups of chicks, G1 to G4, whose complete curves are not shown. The rise in the curve indicates improvement in initial performance probably conditioned by age of the groups. (From unpublished manuscript.)

Each group of chicks was allowed 25 test trials, then returned to the dark. After their second period of practice they were permitted to feed naturally 8 hours a day. The accompanying curve merely shows the initial performances of the four groups. The group tested on the day of hatching averaged less than one swallowing reaction in twenty-five trials. The day old chicks (group 1) made an average of 1.8 swallowing reactions, the two-day old chicks (group 2) scored 2.64

[18] Bird, Charles, "The Effect of Maturation Upon the Pecking Instinct of Chicks." *Ped. Sem.*, Vol. 33, 1926, 212–234. Also *Ped. Sem.*, 1925, Vol. 32, 68–91, and from a manuscript supplied for the author.

and the three-day old groups averaged 3.58. The second day's performance of group 1 was 2.9 after 25 practice trials, a record almost equalled by group 2 which started on the second day with no practice. The second day's performance by group 2 was 5.6 while the first performance of group 3, the same age as group 2, was 3.58 with no practice. The first performance of group 4, 4.63, almost equalled the second performance of group 3, which was 5.10. Hence only a small amount of improvement, if any, between the first and second days' practice was conditioned by that practice. The difference might have been caused by the greater vitality of the chicks which had been given an opportunity to eat.

Another significant feature of Bird's findings is their relation to Snoddy's work on the recess period. Snoddy has emphasized more than any other investigator of the learning process that an interval of time between repetitions is more important than frequency of repetitions. What Bird found when there were no repetitions is precisely what Snoddy is referring to in stressing the importance of recess periods, namely, maturation. *The learner 'grows' to a more difficult and complicated task between repetitions.* This means that upon attacking the problem again he is able to construct a more complex perceptual configuration; he perceives the goal and the method of reaching it in a greater detail of relationships.

The Rôle of Repetition. These experiments, among many others, explain the value of repetition. Provided the repetitions are appropriately spaced the learner is furnished an opportunity to progress step by step toward the achievement of an end. These steps are more limited in some learners than in others because of different rates of maturation and also for the reason that chance circumstances afford more 'cues' in one case than in another. Conditions not under control will also result in a more rapid advancement in the same learner at different periods in the learning process. It frequently happens that the learner shows *flashes of insight* after continued practice during which he has apparently made no progress. Were it possible to control the circumstances under which these flashes of insight appear, there would be no learning of the type so frequently designated as 'trial and error.'

Should repetitions be distributed to the learner's disadvantage an *accidental* value might accrue from them. Under these conditions trial and error procedures consume most of the learner's time, but in the course of making random efforts the relationship of the learner's position with respect to the goal is constantly changing. Chance juxtapositions of these relationships may occasionally lead to unexpected discoveries of correct methods. In this way it happens that learning occurs *in spite of rather than because of an attempt to control and facilitate the process.* This does not mean, however, that repetitions should be employed as means of learning (see page 323).

There is another sense in which repetition is a condition of learning. By definition learning is a repeated goal-activity, but it involves a constant change of means to an end, and a constant elaboration of the goal. Any learning process illustrates the changing of means to an end. The rat in a maze forsakes one route for another in finding the goal; the amateur golf player changes his motor co-ordinations as he gains insight into methods of hitting the ball; the typist is constantly executing new sets of finger movements as she acquires a mastery of the keys. The relationship of single repetitions to the end product is constantly changing. In fact the ultimate achievement may be quite independent of the repetitions made earlier in the learning process. Few or many repetitions result in the same type of learning process depending upon the learner's rate of maturation. For example, some golf players make excellent scores the first time; others could attain the same score if they possessed the same degree of insight.

In dealing with the general problem of repetition, repetition of response should be distinguished from repetition of stimulation. It is the former that is implied as a causal agent by the law of exercise. Those who accept the law assume that definite pathways in the nervous system are by use rendered more capable of functioning in a given performance. While this supposition is untenable, *repetition of stimulation is unquestionably a condition of learning, not because it leads to the use of the same nerve patterns over and over again but because it induces maturation when the stimulation is properly*

timed. Hence the essential thing in learning is not the fixation of 'pathways'; it is the differential use of more 'pathways,' practically the opposite of fixation.

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CHAPTER XI

LEARNING: THE MORE PRECISE FACTS AND METHODS

The Effect of Interrelationships of Habits upon Learning

(1) Retroactive Inhibition. In 1900, Müller and Pilzecker[1] brought to the attention of investigators in the field of learning a phenomenon which they called *retroactive inhibition,* an interference with the retention of a given material caused by activities interpolated between practice periods or introduced immediately after the learning. Is it possible, for example, to study economics immediately after studying history without interfering with the retention of the history lesson? Müller and Pilzecker found a retroactive inhibition of this kind in their investigation and explained it as an interference with a neural 'setting-process' which was supposed to take place after a work period. They reasoned that the neural elements involved in learning gradually diminished in their activity after the work period had terminated. Hence they classified retroactive inhibition as a phenomenon related to retroactive amnesia (page 284). They proposed two laws: (1) Retroactive inhibition is proportional to the difficulty of the interpolated task; (2) it is inversely proportional to the time interval between the original learning and the interpolated task.

In 1915, DeCamp[2] suggested that retroactive inhibition varied directly as the relative identity of the material learned; it resulted from an interference with the setting process by

[1] Müller and Pilzecker, "Experimentelle Beiträge zur Lehre vom Gedächtnis." *Zeit. f. Psy.,* 1900, Ergänzungsband I., 300.

[2] DeCamp, J. E., "A Study of Retroactive Inhibition," *Psy. Mon.,* 1915, Vol. 19, No. 84.

those elements in the interpolated task that were similar to the original. After an elaborate investigation of the problem in 1920, Robinson[3] came to the conclusion that while the degree of retroactive inhibition was a function of the similarity between interpolated activity and original learning, it was impossible to deduce any definite law from the facts. When the similarity between the interpolated and the original tasks reached a certain point the former might become an aid rather than a hindrance, as when the two sets of material were logically related. Summarizing the literature on this subject, the interference of one task with another takes place when the materials are similar but not logically related (such as learning four-place numbers and before recall takes place, multiplying numbers mentally). The degree of inhibition varies, (1) with the degree of learning of the original material, (2) with the subjects employed and (3) with the length of the original material to be learned. The inhibition is not ascribable to the blocking of a setting process, since more recent work has shown no relationship between the inhibition and the temporal position of the interpolated task; it is a matter of 'transfer' (see below). We may suggest the theory that when engaged with interpolated tasks the learner is still behaving with respect to the original goal, namely, to recall the prescribed material. The response is unfinished, but other activities are introduced which do not conform to the original configuration. The response previously initiated and still demanding completion incorporates foreign responses, because recall of the interpolated material becomes part of the goal.

(2) The Problem of Transfer of Training. In recent years much attention has been given the question: To what extent and under what conditions will learning one task *aid* in the learning of another? Experiments show that learning one kind of material is followed by a more rapid learning of another kind under at least three conditions: The first of these is similarity of content; the second is the possibility of emphasizing similar methods; the third is the possibility of assuming similar attitudes. In short where the responses involved

[3] Robinson, E. S., "Some Factors Determining the Degree of Retroactive Inhibition," *Psy. Mon.*, 1920, Vol. 28, No. 128.

in the several activities *can be duplicated* there is said to be a 'transfer effect.' As a matter of fact there is no specific transfer, as many recent studies indicate.

For example, Ewert [4] experimented on several subjects who learned a star-pattern with the right hand by the mirror drawing method. Then they shifted to their left and began immediately to trace the star with a facility which far exceeded their first performances with the right hand. This was not a transfer from the right to the left hand, for while they were learning with the right they were also learning with the left. This can be explained as follows: The learning was accomplished by the organism-as-a-whole; neural integrations were not confined at the outset to avenues between the eyes, the right hand and a limited section of the brain. Rather, the brain as a whole was involved or at least nerve patterns permeating a large proportion of its structure. Still reacting as a total organism, the instant the observer commenced tracing the star with his left hand he already found the task practically learned, for the same central patterns continued to function. In other words, the control of the performance was originally not in the right hand but in the brain as a whole, and as a whole it continued to control the performance when the left hand was substituted for the right.

Lashley's Experiments on Transfer. To illustrate this theory again, suppose a person were to familiarize himself with a set of pictures, his left eye closed. Then with the right eye blindfolded and the left eye open would the pictures seem strange? In this connection an experiment by Lashley [5] is pertinent. Lashley blindfolded the left eye of a white rat while he trained it to avoid the brighter of two lights in a problem box. When there had been no error for thirty consecutive trials he transferred the blindfold to the right eye. The animal continued to show perfect discrimination! As Lashley explained it the nerve routes from the left eye proved at the outset to be equally as well integrated with the avoiding reaction as

[4] Ewert, P. H., "Bilateral Transfer in Mirror Drawing," *Ped. Sem.*, 1926, Vol. 33, 235–249.

[5] Lashley, K. S., "Studies of Cerebral Function in Learning. VI. The Theory that Synaptic Resistance is Reduced by the Passage of the Nerve Impulse," *Psy. Rev.*, 1924, Vol. 31, 369–376.

were the routes from the right eye after the latter had once been integrated.

His results on a *Cebus* monkey were still more striking. First, he paralyzed the left arm and hand of the animal by a brain operation, then trained it to open a latch box with the right hand. When these co-ordinations had been learned he paralyzed the animal's right hand and arm by another operation and after waiting for the right hand to recover he again tested the monkey. Meanwhile it had learned the use of its left hand again in other manipulations. When confronted with the latch box it fumbled clumsily at the catches with its right hand and then, with no random movements, attacked the fastenings successfully with its left. *There was an almost perfect 'transfer' of the habit to the hand which had been paralyzed during the original training.*

It is curious that facts such as were pointed out by Ewert and Lashley had not previously been taken into account in relation to theories of learning, for facts of a similar nature had been known for a long time. As early as 1885, Volkmann discovered that an observer could learn to increase his sensitivity to localized touch on the skin of the right hand 100 per cent in a few hours, immediately after which the same fineness of discrimination was observed on the skin of the left hand!

Once more the evidence points to configurational principles. The neuromuscular system as a whole is an important factor in determining the functioning of its parts. The activities of an unpracticed eye or hand are controlled by the total system of which these organs are members. When a configurational response is built up in one situation the conditions are satisfied for the achievement of similar goals in other situations.

The Motor Aspects of Learning

Recitation as a Factor in Memorizing. Recitation is another condition of learning. Katzaroff[6] attacked the problem as early as 1908, and since then various studies have agreed

[6] "La rôle de la récitation comme facteur de la mémorisation." *Arch. de Psy.*, 1908, Vol. 7, 224–259.

in pointing out the advantage of recitation in memorizing, provided the recitation is properly controlled. Space does not permit going into the experimental work in detail. We may select as typical of results in this field Gates'[7] conclusions from a study in 1917, in which he used both nonsense and significant material on children and on adults. (1) He found that in the case of nonsense syllables appropriate recitation will result in learning twice as much material for immediate reproduction as will a method of reading alone, and four times as much for a recall delayed three or four hours. (2) The optimum combination of reading and recitation for meaningful material gives results 27 per cent better than reading alone in the case of immediate recall, and results twice as good in delayed recall.

The following reasons why recitation facilitates the learning process are suggested by Gates and other investigators: (1) Recitation amounts to additional practice; (2) it leads to a greater certainty of knowledge; fewer blunders and erroneous recalls are made; (3) it furnishes a means by which the learner measures his progress; his knowledge of results becomes an incentive; (4) the meaning of the material is understood more readily; expressing oneself with respect to the material furnishes an opportunity for the formation of added 'associations'; (5) it furnishes an additional avenue of impression through the articulation of words.

These practical facts about recitation should be applied by every student in mastering his lessons. The individual who 'recites' as he studies has an advantage over the student who works silently. It should be remembered there are many possible forms of recitation: (1) Reading the subject matter aloud, (2) attempting to formulate the passages of the text into one's own words, (3) asking oneself or some other person questions about the lesson, and (4) arguing about the facts with oneself or another person. In configurational language, recitation compels the learner to formulate more definite goals and increases the tension under which he learns by introducing a social factor.

[7] Gates, A. I., "Recitation as a Factor in Memorizing," *Arch. of Psy.*, Vol. 26, No. 40, 1917.

Periodicity in Performance. Much time in recent years has been devoted to a study of various rhythms or periodicities appearing in connection with continuous work. There is, in fact, a periodicity about everything we do; heart action, breathing, eating, sleeping and the like, occur rhythmically, under undisturbed conditions. Many individuals do their best intellectual work early in the morning, others prefer working late at night; each has his definite work rhythms. The fatigue curve ordinarily obtained in the ergograph experiment reveals rhythms of muscular contraction of higher and lower amplitudes (see Figure 20). The knee-jerk elicited at frequent, regular intervals over a prolonged period shows the same phenomenon. Workers in factories who make stereotyped movements for hours at a time show periodic fluctuations in their output.

Wheeler has found evidence of the most striking periodicity in a recent study of blindfold maze tracing under series practice of two hours or more in length, when the repetitions followed upon one another so rapidly that the subject was not permitted to relax. If time units are taken as the means of measurement, waves appear in the learning curve not only of approximately equal length for each subject, but of a distinctly characteristic pattern. In many subjects the low points in the curve at the end and beginning of a wave can be predicted in advance with almost mathematical certainty, using the contour of the first part of the curve as a basis (see Figure 31). Quite as striking as the mathematical constancy of the periods is the fact that the subject's attitudes, determination and willingness fluctuate with these waves; both the degree of motor co-ordination and the observer's 'mental state' change according to some basic metabolic law. By detecting the character of his co-ordinations the enterprising observer is able to foretell either a 'good' or a 'bad' period. No amount of voluntary effort will change these rhythms unless, of course, the observer fails to co-operate in the experiment.

The Problem of Muscular Skill. All along in our discussion of the learning process we have been dealing with the development of new motor co-ordinations of different kinds, or in other words, with the acquisition of skill. We have

seen that skill has been regarded as a fixation of motor habits according to the laws of effect, exercise, frequency and recency. Furthermore, we expressed the opinion that assumptions rather than facts had led to the formulation of these laws. First, among these assumptions was the notion that parts are primary. Second, the assumption was made that at the beginning of the learning process movements were purely of a trial and error variety. Having made these assumptions

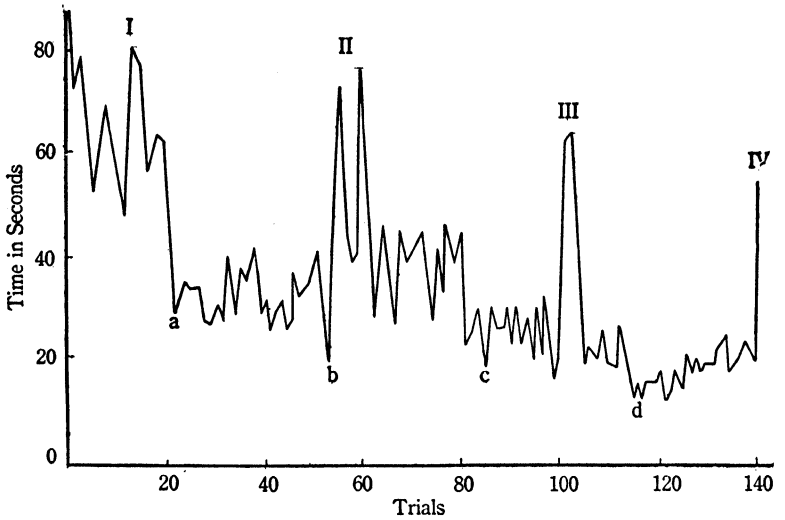


FIG. 31. CURVE OF BLINDFOLD MAZE TRACING SHOWING PERIODICITY.

This is a curve of a single subject, obtained in the author's laboratory, who made 140 consecutive tracings of the maze. Steeples (I to IV) appeared at regular intervals of approximately 40 circuits. Low points in the curve, marking the limits of fairly well defined waves, occur at 30-circuit intervals. Curves of different subjects show a wide variety of waves, some contours of which are more, some less distinct, but all curves reveal a periodicity.

it was necessary to conceive of a principle by means of which accidentally successful or appropriate movements could be selected and fixed. In this theory, of course, unsuccessful movements were supposed to drop out through lack of repetition. We have seen all along that the validity of these assumptions and laws is in doubt, but we have not systematically inspected the evidence pointing to a substitute theory with respect to muscular skill. Pertinent facts have been revealed in

Snoddy's experiment on mirror tracing, to which we have previously referred.

Snoddy's Contributions to the Theory of 'Trial and Error' Learning. Snoddy was able to analyze minutely the movements made by his subjects. In order to understand his findings it will be necessary to inspect the musculature of the arm. As in most parts of the body, muscles of the arm are arranged in antagonistic groups. For example, on the back of the forearm are extensor muscles which are used in straightening the fingers; on the under side of the arm are flexor muscles which function in bending the fingers. Likewise, on the back of the upperarm are the *triceps* which are extensor in character, and on the front side are the flexor muscles or *biceps*.

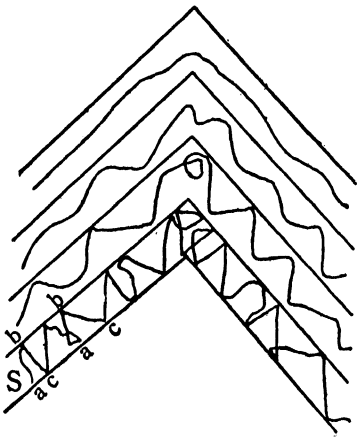


FIG. 32. REPRESENTATION OF PROGRESS IN MIRROR TRACING (Snoddy).

(1) Typical path traced by the learner around one corner of the star-pattern early in the course of the learning process. (2), (3) and (4) are tracings made around the same corner at successively later stages in the learning, showing the effects of a progressively better balancing of flexor and extensor muscles.

If we study Figure 32 carefully we see that the learner begins *by making simple extensor and flexor movements*. He pushes his hand from *a* to *b* by an extensor thrust of the arm, and then by the use of flexor muscles he pulls the hand back to *c*. Superficially these might be construed as random movements which must sooner or later drop out, because they are not directed toward the goal. According to the trial and error theory of learning, the movement that carries the hand straight down the path is made accidentally, and is separate from the zig-zag movements which we have just described. But the tracings do not bear out this assumption. Notice that the successful movement is a gradual evolution from the so-called unsuccessful ones.

What would happen if the subject contracted both the flexor and extensor muscles at the same time? A *resultant movement* would take place in an entirely different direction from that of the pure flexor or pure extensor movement. Snoddy found that the successful movement was a resultant of this sort. Accordingly, his subjects learned to travel straight down the path when they *discovered* how to balance their extensor against their flexor muscles. This means that the so-called random movements were not eliminated, and neither were they combined into a successful movement. Rather, the successful movement was an entirely new one, involving the balancing of *two sets of muscles* which hitherto had been functioning separately.

The Initial Delay. The problems arise, therefore, what conditions the formation of these new co-ordinations? In what sort of process do they originate? Figure 33 gives us a possible clue. Snoddy was able to measure the speed of movement along the pattern by means of a camera and an interrupted electric light fastened to the stylus with which his subjects traced the star. The black dots represent single flashes of the light and the distance between them indicate the speed of arm movement. Notice that immediately before the subject turned a corner he slowed down; before he made a *new* movement he hesitated. Snoddy called this a *period of initial delay.* We may interpret its function as follows: The subject slowed down *while he was constructing a perceptual configuration of the path to be traversed.* Indeed, introspective reports showed that as the subject was perceiving the path ahead in its spatial relationship to the rest of the star he was 'setting' his arm in preparation for the correct movement, although he was still moving at the time. When considerable speed and accuracy had been acquired, the period of initial

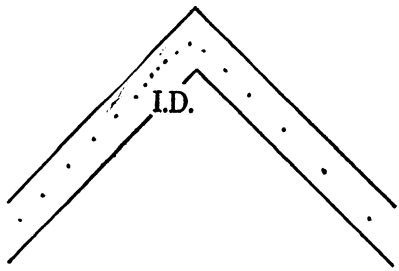


FIG. 33. ILLUSTRATION OF 'INITIAL DELAY' (Snoddy).
Explanation in text.

delay came at the starting point of the star, where the learner poised his stylus, *viewed the star as a whole* and then proceeded around it with a rapid, sweeping movement.

Presumably all co-ordinations arise in this way; they are formed as the learner perceives the goal in its detail of spatial relations. The co-ordinations, then, are the end-products of perceptual configurations. Once the configuration is constructed, the movements take care of themselves. This is why it is not best, in executing delicate feats of skill, to think too much about the muscular movements as such, because then the performer suffers from what is called 'over effort.'

Similar periods of initial delay occur in other types of muscular co-ordination. When a golf player has raised his club, his downward stroke is likely to be awkward unless he hesitates for a moment. During this period he is constructing the action-pattern for the final swing. That the construction of a configuration requires time is seen in many other instances. Lewis' chicks (page 124) frequently *hesitated* before entering the correct compartment, and Wheeler and Perkins' goldfish behaved in the same way. When either animal failed to hesitate it more often made errors! Helson's rats and Lewis' chickens ultimately learned to make their choice from the position in which they were placed in the apparatus, some distance from the lights. The 'initial delay' and the 'choice' are obviously similar phenomena.

Analogous behavior can be observed in children. The author was trying one evening to teach his baby daughter to wave 'bye-bye' on going to bed. He went through the motions and said "bye-bye" just as the child was being carried up stairs; she looked puzzled and exhibited every sign of trying to understand. *The response finally came when she was halfway up the stairs, thus showing that the development of insight required time.* The situation must of necessity be understood first, then the co-ordinations appear as the end stage of the new perceptual configuration. These various periods of initial delay illustrated above are of sufficient importance and frequency in the development of configurational responses to be regarded as *criteria of insight.*

Function of the Stimulus-pattern. If the initial delay prior to the execution of a new performance is a period in which the perceptual-motor configuration is forming, what accounts for the formation of the pattern? It is not insight, as we have defined it, because insight is the conscious aspect of the configuration itself. It is not maturation, wholly, because maturation is that differentiation of stresses in the nervous system that makes possible the construction of new patterns. It is the stimulus-pattern which specifically conditions the perceptual-motor configuration; it induces new stresses in the nervous system. *The patterns of stresses (action-patterns) are forming while the stimuli are functioning and while the organism is responding.* This requires time, and Snoddy's period of initial delay is precisely the period during which the new systems of stresses are developing that terminate any particular movement.

Muscular Co-ordinations and the Law of Least Action. The foregoing discussion suggests how motor co-ordinations follow the law of least action. They depend first, upon the organism's perception of a goal; once the goal is established the organism is under tension, and the motor co-ordinations follow as a resolution of the tension. Second, the goal is constantly becoming more complex, and in accordance with these changes the co-ordinations become more complex. In mirror tracing, for example, the perception of the goal at the outset is very indefinite and vague, for the subject knows only that he is to reach the starting point again after going around the star. He can not at first perceive the goal in relation to the means of reaching it. He makes his initial move and forthwith finds himself to one side of the path. In this new and strange situation he reduces the goal and likewise his muscular co-ordinations, to their simplest terms, those of returning to the path. The most direct action under these circumstances is the contraction of a single group of muscles, either the extensor or the flexor, depending upon the position of the goal. Then, as he constructs a more complex configuration of the goal and the means of reaching it, the least action is a simultaneous use of both extensors and flexors. Hence

the learning process becomes a gradual shift from the successive to the simultaneous functioning of opposed muscles. The movements become easier, but at the same time more complex.

Unless the configurational hypothesis is adopted in interpreting muscular movement *toward an object,* the movement is an unintelligible phenomenon. Otherwise how can it be explained that the movement is made *in the direction of the object and not in some other direction?* The chick just out of the egg pecks *toward* a grain of food; a person sees the glass of water on the table and extends his arm directly toward it; one's eyes move toward an object in the periphery of the visual field (page 485). The ancients supposed that these movements were guided by an act of 'will' but this conception utterly failed to describe the details of the process. Moreover, neither the reflex nor the habit theory accounts for the *directional character* of any movement of the organism. Accordingly, before the configurational theory was conceived, the simplest movements were mysteries. As we have already noted, Loeb adopted a type of configurational theory in accounting for the movements of simple organisms. (Tropisms, page 118.) According to the same general principle, without its mechanistic implications, movements of parts of the complex organism become comprehensible. Reaching for objects, moving the eyes toward objects in the periphery of vision, brushing an insect from one's forehead, and the like, are psychological illustrations *par excellence* of movements in the line of least action. But in these cases the retina (in persons who see) with its point of greatest sensitivity in the center, or fovea, and the area of least sensitivity in the margin or periphery, helps to control the neuromuscular configurations that determine the line of least action.

Returning to the mirror experiment, the expert performer focuses a corner of the star ahead of him. With the corner as a goal and with a gradient of stimulation across the retina from margin to fovea, stresses within the neuromuscular system are so aligned that the most direct movement in time is a co-ordination that guides the stylus in a straight line down the path. Early in the learning process this movement is impossible because the mirror reverses the relationship between

the retinal stimulation and the movement as actually made. It must be remembered, of course, that the detailed conditions which combine to direct the movement are extremely numerous and complex. A distraction, an eye-movement, or some other cause may result in moving indirectly toward the goal. Instantly corrective effort is made, that is, counter tensions develop. Thus it is that any movement not in a direct line toward the goal meets with resistance. In this connection, one is reminded of the old adage that 'water will not run up hill.' The constant effort exerted by the reactor to maintain movement directly toward the goal when disturbing influences interfere, represents in general, a similar problem.

Finally, the question of how the learner happens to perceive the method of reaching the goal has always been a difficult one to answer. It has been customary to assume that when he made a mistake he *profited by experience.* The error was supposed somehow to create knowledge, to inform him of better methods. Whether he made a mistake or a successful movement accidentally and profited by it, or whether he saw in advance what kind of a movement to make, he was doing something *which he had never done before.* He was constructing a *new* perceptual configuration; he was growing or developing with respect to the task. In this sense the learning process throughout involves making discoveries, inventions. As in any growth process, one stage in the development of skill will not account for the next. An old experience will not account for the added increment in the new one; an old motor co-ordination at one stage of the learning will not account for the new co-ordination in the next stage. Accordingly, growth or maturation must be assumed as a basic phenomena in the development of motor configurations.

Conclusions Regarding Theories of Learning

(1) Problems in Connection with the Learning Curve. If learning curves are carefully studied it is evident that the method used in measuring a given learning process determines the character of the resulting curve. For example, if progress is measured in units of work, such as the number of letters

transcribed in five minutes, and these units are plotted against weeks of practice, an *ascending* curve is obtained. The same learning process can be pictured in the form of a *descending* curve. If the slants of these two curves were to be interpreted naïvely, the mistake might be made of assuming that they represented different types of learning. Indeed, this is what actually happened at one time. Ascending curves were obtained in which the learning seemed to take place very slowly at first and then more and more rapidly; descending curves were obtained in which the reverse apparently occurred. Moreover, there are ways of translating these curves into another type which is practically a straight line; then it would appear that the learning occurs at a constant rate throughout. Thus, to make a declaration about the rate of learning one must always bear the units of measurement in mind.

There are additional difficulties with the learning curve. Is it a representation of actual learning or is it a picture of the subject's performance *under chance conditions?* It is possible that if the conditions of learning were under complete control the animal or the human being could solve the problem at the first attempt. Then there would be no learning curve. That a curve is obtained at all may mean that the task is too difficult, *forcing upon the behavior of the learner a chance distribution of conditioning factors.* For example, a rat is in a maze; its learning with respect to the goal prescribed by the experimenter is said to be 'trial and error' although there is no trial and error response from the standpoint of the animal. In trial and error performances a chance distribution of conditions is controlling the learner's behavior, as a consequence of which a chance curve is to be expected. Culler [8] has related it to an *ogive* curve, a frequency curve picturing the cumulative influence of a single determining factor like *time.* Another hypothesis may be offered that the curve represents first, the fact of a chance distribution of conditions and second, the rate at which the experimental method introduces more controls as time goes on. In support of this latter view is the fact that when an observer is first placed in a learning situation his behavior

[8] Culler, E., "Nature of the Learning Curve." (Abstract), *Psy. Bull.,* 1928, Vol. 25, No. 3, 143.

can not be predicted, whereas, after he has learned the task his behavior *can* be predicted. The curve of learning measures the rate at which the experimental technique substitutes controlled conditions for the original chance distribution. More enticing is the view that the learning curve is a special kind of growth or maturation curve. Nevertheless, the problem of what learning curves actually measure remains to be solved.

[**Description *versus* Explanation.** It has been noted that many conceptions of learning are being modified in the light of recently discovered facts. Let us review some of these problems, first considering a question in the logic of scientific theory in order to make the basis of the subsequent arguments plain.

Let A in Figure 34 represent an event. Having only this event to work with we are confined to a description of it. To explain A, the conditions under which it takes place must be known; these conditions are represented by B. Consider A and B together as one event. What was said about B is no longer explanatory; with A, it is descriptive; the event AB must be explained by referring to C. When C is included in the total situation, D must be ascertained before an explanation is possible. Consequently, it can be seen that description and explanation are relative and depend entirely upon the point of reference.

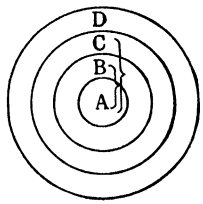


FIG. 34. DIAGRAM ILLUSTRATING THE DIFFERENCE BETWEEN DESCRIPTION AND EXPLANATION.

The following discussion of insight and experience should be read in the light of this logical principle that what is description and what is explanation depends entirely upon the purpose and scope of the problem.]

(2) Inadequacy of the Experience Theory. Considering *the learning process as a whole, we do not learn by experience.* This is contrary to the common sense view based upon the theory that experience is built piecemeal upon fixed and unorganized impressions. Suppose a child touches a hot stove and is burned, always to avoid it thereafter. The instant he touches the stove he has a new experience; he constructs a new configuration; he perceives pain for the first time *in connection*

with the stove. At this exact juncture, what is commonly called profiting by experience *is the learning process.* No one profits by experience unless he has *sufficient insight into that experience to profit by it, in which case it is the insight into the experience which measures progress, not the experience into which he has the insight.* Experience is explanatory only when it is considered as the insight with which a given learning situation is approached. Defined in this way it becomes a condition external to a given event in the learning process; it will not account for progress, however, from one stage of the learning to another because in the meantime insight has *improved.* This means that the problem is attacked with *new* insight. The experience theory also raises the problem of accounting for *the first learning process in the life of the individual prior to which there has been no experience. If the first act in a learning process is not to be explained on this basis, neither is the 10th nor the 1000th.*

(3) **Inadequacy of the Trial and Error Theory.** It is evident that learning does not proceed by trial and error with accidental successes fixed by pleasure and errors eliminated by annoyance. Likewise it is certain that learning does not commence with random movements which are subsequently eliminated by mechanical agencies. 'Trial and error' refers to an imposition of a goal upon the learner to which he is not responding. If the animal or human subject fails to perceive the goal prescribed by the experimenter his behavior is irrelevant and will not become relevant until he apprehends the prescribed goal. In the meantime the behavior which he exhibits pertains to goals of his own. It should be remembered that the aim of this discussion is to account for learning. What has been said does not contradict the fact that both animals and human beings *happen* to learn in 'trial and error' situations, but a recourse to trial and error as a principle of learning merely bases the process upon chance and explains nothing.

We may now answer the question, Why does the animal or human learner fail to repeat so-called trial and error or wasteful movements and why does he persistently repeat the successful movements? He fails to repeat the unsuccessful movement because he has perceived a *different* goal; another

remote end has been established. There has been no dropping out of movements any more or any less than there has been a dropping out of an air current when a low pressure area shifts from one locality to another. *The successful movement is repeated for the same reason that it was made in the first place,* namely, when the stimulus-pattern in which the goal figured presented relationships on the learner's level of insight, that is, fitted his level of maturation. Since learning is a species of growth process, a given level of maturation is not only maintained, under optimum conditions, but continues to rise with respect to a given task until the limits set by the learner's organic structure are reached. Meanwhile, during any particular learning process, fluctuations in efficiency are due to a variety of chance conditions not under control. Reverting to the goldfish experiment for an illustration, how did it happen that one particular light, the brightest, dimmest or medium, came to function as a goal rather than another? (Page 122.) The goal at first was any compartment. Punishment was a stimulus provided in connection with the wrong goal and food was the stimulus provided in connection with the right one. Little by little the correct compartment was seen in its relation to the total situation—the other lights and the punishment. The appropriate configuration was not stabilized by use; rather, it was formed by stimulation, a process which involved continuous maturation.

(4) Inadequacy of the Law of Effect. The law of effect has been disproved by numerous experiments. Snoddy [9] found that more progress was made in star-tracing on the sides which afforded the *least* satisfaction. We know also that there are many unsuccessful and superfluous acts which develop in almost any complicated learning process. Moreover, the assumption that successful acts must be pleasant and unsuccessful acts unpleasant violates the facts of observation in human behavior and is unwarranted with respect to animal behavior. And finally, behavior is not a combination of discrete movements derived by processes of subtraction and addition, as the law implies.

[9] *Op. cit.*

(5) Inadequacy of the Laws of Frequency, Recency and Exercise. The laws of frequency and recency and their corollary, the law of exercise, can also be questioned. *Repetition of response,* as such, is not a conditioning factor. Constructive learning, as we saw it in T. Perkins', Lewis', Helson's, Peterson's, Kuo's and Köhler's experiments, and as has been pointed out by numerous other investigators, takes place directly against expectations based on frequency and recency influences. These laws have proved of doubtful value because they were based upon questionable assumptions; we have already noted these assumptions. First, from the standpoint of self-observation, learning is a building of complex states of consciousness upon simple elements, like sensory processes, images and feeling. Second, from the standpoint of overt behavior, learning is a building of complex bodily movements upon such elements of response as reflexes and conditioned reflexes. These assumptions disregard the impossibility of explaining a whole in terms of its parts. The reason for these postulates should be clearly borne in mind. The trouble came about in this way: The adult abstracts from his complex experiences simpler ones like sensation and feeling, and he abstracts stereotyped contractions, such as reflexes, from the muscular movements of the organism. Hence he supposed that these abstracted elements, *imagined back where they originally belonged, accounted for the original activity. He neglected to observe that by such an analysis of the total phenomenon he destroyed it. This fact alone makes illogical an explanation in terms of the abstracted elements. If he could so arrange these parts again that the whole would return he could no more explain how he then obtained the whole than he could explain why he lost it in the beginning.*

One doubtful assumption led to another. The abstracted elements were supposed to *appear first* in the life history of the organism. Its first 'consciousness' was thought to be an unorganized mass of sense impressions, and its first movements a mass of unco-ordinated reflexes. We believe instead that primitive experiences and primitive movements are undifferentiated and that the differentiated sensory experiences and 'reflexes' develop later (see page 491). The theories just

considered involve still another doubtful assumption, namely, that the learning process is based upon a blind instinct or urge so defined that the organism is driven blindly toward a goal. If we are to accept this assumption, *the organism possesses no insight in terms of which to perceive the relationship of its drive to the goal. It then becomes necessary for the theorist to provide a mechanical means like a stamping in by pleasantness or a fixation of a habit by frequency, to bring the organism to the goal.*

(6) The Problem of Maturation. Logical argument and factual evidence have been accumulating throughout the text in favor of maturation as a basic condition of learning. It was implied in Chapter II in a discussion of the development of personality. It was seen in its grosser aspects in the evolution of behavior in the animal scale through the primates as far as civilized man (Chapter V). A similar phenomenon was observed in the development of intelligent behavior in the child, and it has stood out at every step in an investigation of the learning process. The crucial evidence appeared, first, in the fact that both animals and human beings were able to meet *new* situations of certain degrees of difficulty the first time they tried. Second, when the organism was confronted with the same environmental situation repeatedly there was a constant and progressive change in its behavior toward a more complex, differentiated and at the same time, organized response. The conclusion is inevitable that a growth process goes on within the organism both before and after it has reached the limit of its size and weight. It is a development which makes possible a solution of more difficult tasks, that is, a response to stimulus-patterns of greater detail perceived in wider relationships. But the problems remain, what is the nature of this maturation? What are its conditions?

The Possible Nature of Maturation. In answering the first question it will be possible only to speculate upon various alternatives. *First,* we know that every structure undergoes a change with the course of time. By whatever way the earth attained its size there are qualitative changes still taking place within it. After it has grown to its full size an apple undergoes a ripening process that ultimately ends in decay. In

human beings maturation is one phase of that continuous process which in its later stages is popularly called 'growing old.' We know certain of the characteristics of this change, but only enough to indicate that maturation involves changes within the tissues. Muscles harden and eventually lose their flexibility; the water content of the nervous system decreases, and metabolism in general becomes more sluggish. There may be a gradual change akin to ossification or a laying down of precipitates. It is, in part, to the reverse of such processes as these that we must look for the nature of maturation as we observe it in learning.

Second, maturation is almost certainly a *differentiation* of energy patterns, or systems of stresses in the nervous system, which are organized as they differentiate. Whether or not they take the form of more complex organic compounds or whether or not they are similar to patterns of 'electrical potentials' can not be said. A structural change in already matured nerve cells, such as a growth of intercellular connections (see page 496), is possible, although there is more likely a growth of hitherto undeveloped cells whose gross structures are laid down early in life.

Third, maturation may prove to be a formation of physiological gradients (see page 490). We know that gradients exist on a gross scale in all organisms. By physiological gradient is meant differentials in irritability, or metabolic rate, the rate of living of the tissues concerned. For example, there is a general gradient extending in one-celled animals from the surface of the body toward the interior, the surface being more sensitive than the interior. In complex organisms there is not only this gradient but there are others, extending throughout its length, in which in one case the head-end and in the other case the tail-end exhibit the highest rates of metabolism. It is known that within these major gradients, subsidiary ones develop that always sustain definite relations to the whole.

Fourth, a more specific view of maturation is found in Köhler's hypothesis of 'non-process changes' (page 276). While we would prefer to envisage these changes as broader in scope than Köhler indicates, his thesis seems plausible that

a change, effected in the nervous system by an external stimulus, demands a mutual adjustment between itself and pre-existing systems of stresses. As a result of this adjustment, new modes of behavior and new experiences are made possible, provided stimulations occur fast enough to keep the stress patterns within the nervous system increasing in their complexity. This condition would be satisfied if changes in stimulation came often enough to prevent a return of the patterns concerned to a state of equilibrium, for then new changes never become completely adjusted to pre-existing patterns. In simpler language, stimulation produces a change against which there must be a reaction, a rebound, but since the rebounds are never completed the total situation in the nervous system is constantly becoming more complicated. Hence the rebounds result in processes of differentiation. This theory helps us to understand the necessity of recess periods in learning, for the adjustments require time. The logic of the theory is not altogether different from the older conception that a 'setting process' took place in the brain after every sense impression, but it substitutes the notion of growth or progressive change for the idea of traces.

The Conditions of Maturation. In suggesting an answer to the second question, it is unfortunate that we can not penetrate the living nervous system to ascertain what goes on! Nevertheless, in other parts of the body progressive changes can be observed that are direct products of stimulation or irritation. In fact, growth anywhere seems to be a function of stimulation. Callouses on one's hand and corns on one's feet develop from rubbing; monstrosities in the shapes of organisms can be produced experimentally by altering the pressure of the medium in which the embryos are developing; irritation is one cause of tumors! Instances of this sort could be multiplied almost indefinitely. We are led to the presumption, therefore, that if maturation is a species of growth, one of its main conditions is stimulation. In addition, anything which affects the physiological processes going on within the nervous system would be a condition of maturation, for example, food, oxygen, temperature and the presence of toxic substances, all

of which are the subject matter of physiology rather than psychology.[10]

The Axiomatic Aspect of Maturation. Finally, there is as aspect of maturation that remains unexplained. Maturation is clearly the outcome of an interaction between the organism and its environment, but when all of the conditions are assembled, it is not known ultimately why the organism responds at one time by growing and at another time by disintegrating. Moreover, the facts are unavailable that will finally account for so profound an event as evolution in the animal kingdom; accordingly, the general course of evolution in the future is unpredictable. Likewise, the direction of mental development in the individual is predictable only within certain limits. The exact circumstances under which an individual will develop into a Shakespeare, or a Napoleon, or a Lincoln can not be foretold; it can not be predicted what words an infant will learn first, what new ideas the child will invent, what new observations he will make and what questions he will ask. Even in the physical and chemical realms evolution, growth and maturation are replete with surprises, in spite of a fair degree of control. All this is because science deals with abstractions, or parts of wholes, as well as with wholes. The functioning of wholes can not be predicted alone from the properties of their parts. Accordingly, when two types of energy systems, not hitherto observed to unite, articulate for the first time, the outcome is unpredictable. Out of the 'union' there emerge new facts, new existences! It is this *emergence phenomenon* which is unexplainable in the light of our present knowledge; as yet it is by definition a fundamental, an axiom.

(7) The Function of Repetition of Response in Learning. With these considerations in mind the rôle of repetition of response in learning can be more adequately understood. *It bears the same relation to maturation and learning as time bears to growth.* Time does not explain growth because it furnishes no clue as to how growth proceeds, nevertheless time figures in any mathematical formula to which the facts of growth are reducible. It is the same with the repeti-

[10] Cf. Coghill on maturation. Reference on page 476 this text. Also page 495 this text.

tion of response, the concept of which throws no light upon learning. The reflection is illuminating in this connection, that time resists control and must therefore figure as an unexplained constant in any discussion of growth. To be sure, the length of time an organism is permitted to eat may be controlled, so too, the length of time it is permitted access to light, to optimum temperature and oxygen; and as a consequence, growth can be controlled. But in all of these instances the explanatory conditions are factors other than time, namely, the amount of food, oxygen, and heat. So with repetition of response in respect to learning, whatever the relationship of repetition as such to learning, it is an uncontrollable factor, a constant in the learning formula. Hence to assert that we learn by doing, or learn through exercise is as meaningless as to claim that we grow by living in time. Now it happens that repetition is associated with factors that can be controlled, so that with the apparent control of repetition there is an inevitable manipulation of stimuli and a varying of time intervals between stimulations, during which the organism has changed and the goal has changed; indeed, the entire relationship between the stimulus-situation and the organism has changed. During the manipulating of repetitions we have been controlling *other factors* to which the progress of learning must be attributed. This view recognizes the close relationship of repetition to the learning process without assuming the repetition to be a dynamic condition of progress; rather, the view portrays repetition as a non-explanatory condition, namely, the temporal aspect of the learning process. Accordingly, a single repetition is a section of the learning process. In order to complete the account it is to the functioning of stimulus-patterns repeated at the proper time intervals and to the level of maturation that we must look for explanations. The interrelations of these two factors have already been discussed in detail (page 311).

A practical consideration follows from this view of repetition, namely, that the learner should take repetition for granted and instead of emphasizing *it* as a condition to control, emphasize *others factors,* like the time interval between, the definiteness of the goal, the learner's own level of insight,

various 'incentives' and distractions, the rhythm of the process, the method of procedure (whole *versus* part) and so on. The progress that is attributed to repetition, made under conditions of drill, cramming, rote memorizing and the like, is achieved in spite of, not because of an attempt to control repetition. It should be remembered, also, that attempts to control this factor often mean the instituting of conditions that impede rather than facilitate maturation.

(8) Summary of Configurational Account of Learning. (1) Learning rests first, upon a given degree of maturation in the nervous system and second, upon the functioning of stimulus-patterns that cause a new alignment of stresses in the nervous system. Seen in its totality, this new adjustment is the development of a new perceptual-motor configuration.

(2) The total event just described takes place under circumstances which determine lines of least action; the response commences as a tension which demands resolution toward a remote end. The 'end' is represented in the stimulus-pattern by a goal, and in the organism by an equilibrium of tensions between its own stresses and the forces of the stimulus-pattern.

(3) Because of the configurational character of learning, special attention should be paid to the goal; the whole method is in the long run superior to the part method; incentives are best construed as energized learning, not as separate agencies in the learning process; forgetting is learning going on under practical handicaps, and transfer is a case of the whole determining the functioning of its 'parts.'

(4) Because maturation is one of the major conditions of learning, recess periods are essential. Periods of no progress are signs that the learning process is improperly controlled. The maturation that occurs during the recess period is a differentiation process which makes possible more complex configurational responses upon the next functioning of the stimulus-pattern.

(5) The configuration develops as an interaction process between the level of maturation in the nervous system and the forces of the stimulus-pattern. It is convenient to interpret the stimulus-pattern as the condition which *forms* the

configurational response. The stimulus-pattern is both external to the organism and intra-organic.

(6) As seen from the standpoint of conscious behavior, the development of a configurational response is the growth of insight. Insight, then, depends upon the organism's level of maturation and is induced by the stimulus-pattern.

(7) These principles are substitutes for the mechanistic laws of association and for the assumption that organized responses are built upon unorganized and unrelated sense impressions and reflexes.

(8) Finally, the learning process proves to be a form of intelligent behavior that inevitably takes place when the organism faces problem situations repeated at intervals of time. It is a function of (a) maturation, (b) the repetition of stimuli, (c) the time intervals between repetitions of stimuli, (d) the relation of the problem to the learner's level of maturation, (e) the completeness with which the stimulus-pattern is repeated and (f) the degree of tension under which the learner is behaving.

We have attempted to confine our theorizing to the facts that logically compel it. Since there is always a chance of prejudice, and since views contrary to those expressed here are still widely accepted, the student should carefully study these other views and refrain from drawing conclusions of his own until he inspects whatever evidence and argument are contributed by other standpoints. In doing this he will find these and previously mentioned references helpful.

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CHAPTER XII

SIMPLE REACTION AND OBSERVATIONAL BEHAVIOR

Simple Reaction Behavior

Introduction. We now turn to a consideration of simpler modes of behavior than those which we have studied heretofore, and, following the plan of the text, we shall consider the conditions of response to be more restricted than was evident in previous discussions. This increased restriction of conditions means that out of the behavior previously examined, certain more limited events will be abstracted for the purpose of specialized study. For instance, we have been studying goal-activities all along under social, intelligent, emotive behavior and learning, but we have not subjected to scrutiny a typical form of goal-activity, reduced to its simplest terms, as we find it in the *reaction-experiment.* Moreover, all forms of behavior studied thus far involve processes of observing which have not, as yet, been isolated for detailed investigation. These processes have been mentioned frequently under the name of perceptual configuration. The present chapter is concerned with simple reactions and with the general aspects of perceptual configurations.

The Reaction-time Experiment. The object of the *reaction-time* experiment is to measure the speed with which an individual can respond to a given stimulus. For example, if you should prepare yourself to strike the top of your study table as quickly as possible when your roommate gives you the signal, an appreciable amount of time would elapse between the signal and the contact of your hand against the table. This is your reaction-time. Reaction-times of this sort are important elements in many practical situations. You may

avoid an automobile accident by having a quick reaction-time. Those who make the fastest get away at the crack of the pistol are at an advantage in a hundred-yard dash. Basket-ball, tennis, any competitive sport requiring quick, co-ordinated motions, abounds in illustrations. In the days of dueling and pistol fights quick or slow reaction-times often meant the difference between life and death.

There are numerous instruments by means of which under a variety of conditions we can measure an individual's reaction-time. The instruments range from the ordinary stop-watch to the most elaborate and expensive 'chronoscopes' which record intervals of time in thousandths of a second (sigma), and better. Figure 35 shows the Vernier chronoscope, a simple device which measures time to thousandths of a second fairly accurately. The pendulums are so adjusted in length that one, the shorter, beats 78 times per minute and the other, the longer, beats 76. If the longer is released from its clamp by pressing one key and the other is released a fraction of a second later, the shorter will gradually overtake and for an instant beat synchronously with the other. The difference between the duration of single swings of the two pendulums is twenty thousandths of a second, hence if we count the number of swings made by the shorter in catching up with the longer and multiply that number by 20, we have a measure, in thousandths of a second, of the time elapsing between the releasing of each pendulum.

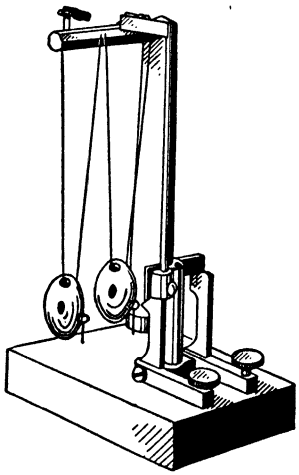


FIG. 35. THE SANFORD (Vernier) CHRONOSCOPE.

Problems of Reaction-time. Problems in connection with reaction-time are altogether too numerous and varied to consider in detail. We might be interested in ascertaining, (1) the conditions under which reaction-times are the shortest, (2) the conditions under which they lengthen, (3) the aver-

age reaction-times of large numbers of individuals under similar conditions and (4) the consistency of reaction-times in the same individual under conditions that are kept as constant as possible. (5) We might make an analysis of the individual's behavior during a reaction experiment or (6) we might abstract the reaction 'consciousness' from the individual's behavior, and (7) determine the relationship between the preliminary and final stages of the reaction.

The shortest obtainable reactions average about 120 sigma, although certain observers complete their responses in as short a time as 80 or 90 sigma, while others require 150 to 180. The conditions which produce reactions of this brief duration in the laboratory are: (a) instructions to emphasize the finger and arm movements and to ignore the type of stimulus that is given, and (b) an auditory stimulus to which the subject reacts blindfolded, thus eliminating visual distractions. Such reactions are called *motor* because the observer emphasizes muscular readiness.

There are numerous means of lengthening a reaction-time. In the simplest procedure the observer listens carefully to the sound stimulus with the aim of inhibiting any reaction to a false sound. Another method is to present the observer a variety of visual stimuli with instructions to react to red, let us say, but to no other color. These reactions range around 250 sigma and are called *sensory* because the individual is attending to the stimulus. There is no end to the complications of the reaction-experiment. Apparatus may be used in which the observer is to react with the right hand to one kind of stimulus and with the left to another kind. This is called the *choice reaction,* which runs on the average to about 500 sigma. In still another procedure the observer is presented a word and instructed to respond as quickly as possible with the first word which the stimulus suggests to him. This is called the *free association-reaction.* Again he is given a word and told to respond with another whose meaning is the opposite of the stimulus word. This is an example of a *controlled association-reaction.* And finally, pairs of meaningless syllables are exposed to the observer; subsequently the first member of the pair is presented as a stimulus, with instruc-

tions to respond with the paired associate. One may also study the effects of drugs, loss of sleep, narcotics, alcohol and the like upon reaction-time. The reaction-method, or some modification of it, has been the outstanding procedure in laboratory technique since the dawn of psychology as an experimental science.

Analysis of Reaction-behavior. It is convenient to divide the reaction-behavior into three periods; the *fore-period,* beginning with the instructions and lasting until the signal is given; the *main-period,* which begins with the signal and ends with the termination of the observer's reaction, and the *after-period,* which lasts for a brief interval following the reaction.

Behavior in the fore-period is characterized by the observer's apprehension and acceptance of the instructions, by an anticipation of the signal and preparation for the movement. If we were to analyze these events of behavior in detail we would find them extremely complex. The principal point to be emphasized about the fore-period is the fact that the actual reaction commences *then.* The observer goes through the first stage of perceiving the stimulus when he anticipates it; he has partly reacted when he tightens the muscles of his arm. If we proceeded farther in our analysis we would discover that the anticipation of the stimulus consists of hearing it in advance in terms of imagination of the sound (auditory imagery), together with a possible visualization of the experimenter with his finger poised above the stimulus-key. The observer also anticipates the stimulus with the aid of inner speech, or auditory-vocal-motor imagery, such as, 'It's coming soon,' 'Now,' and the like. Whatever his method of anticipating the stimulus, he finds himself becoming more tense as the seconds elapse just prior to the signal. With this preparation the reaction follows automatically and inevitably when the signal is given; it is the final stage of the reaction that has already commenced. *The reaction is an illustration par excellence of behavior directed by a goal and consummated in a sudden reaching of the goal.*

Reaction-behavior and the Law of Configuration. For a time the view prevailed that the observer's acceptance of the

instructions (Aufgabe) directed the subsequent train of thought by means of a determining tendency functioning according to the laws of association. In the view of the configurationists the instructions and experimental setting stimulate a perceptual response involving a goal and the inducing of tensions toward it. The reaction commences the instant the 'end' is established. It is not necessary, therefore, either to assume a determining tendency or the laws of association. Rather, the reaction is organized in the development of the perceptual configuration and the entire reaction proceeds under its own organization to its own end which is a resolution of the tension.

What, it may be asked, accounts for the organized character of the response? In the first place the phrase, 'insight into the total situation,' *describes* the organized character of the reaction and denotes the novel character of the response. In the second place the general level of maturation which the subject has attained at the time brings him into relation with a complicated array of stimuli: the instructions, the apparatus and the bodily position of the reacter (stimuli from the muscles). Suppose an analogy is considered in this connection. The level of maturation which is characteristic of the reacter's nervous system as a whole corresponds to a pattern of air currents in a given locality. The stimulus-pattern corresponds to a pattern of currents in another locality. Given these two patterns whose pressures differ there will be a shifting of the currents from one of the localities to the other. The organization of currents in the one region will depend upon the organization in the other. Similarly, the stimuli to which the observer will react depend upon the alignment of potentials within the reacter's nervous system and in turn, these potentials are organized by the stimulus-pattern. In other words, given as a basis a level of maturation with its potentials, *the stimulus-pattern then forms or sets up the organized reaction.* The same principle holds for behavior in general.[1]

Methods of Measuring the Strengths of Opposed

[1] It must be remembered, of course, that in the case of behavior, the potentials within the organism involve much more energy than is represented in the stimulus-pattern, and by far a more profound organization.

Reactions. Several years ago Ach[1a] devised a way of measuring opposed tensions produced with respect to conflicting goals. First, his observers learned pairs of nonsense syllables, like tes-pon, jeb-wud, and so on, very thoroughly. Second, he exposed the first member of a certain pair with the instructions to respond with the associated syllable. Third, he instructed his observers to react, not with the paired associate, but with a syllable which rhymed with it or with a syllable whose letters were the same, but arranged in reversed order. He found it possible for his subjects to learn the original paired associates so thoroughly that they responded with the associate in spite of instructions to the contrary. In this way he aroused two tensions, the one caused by the goal of responding with the paired associate, the other by instructing his subjects to react with a rhyme or reversed syllable. When the first tension was strong enough to inhibit the second, he regarded it as equivalent in strength; he measured this strength by the number of repetitions required in learning the paired associates sufficiently well to produce the inhibition.

Lewin's Repetition of Ach's Experiment. In 1922, Lewin[2] obtained some very interesting results bearing upon Ach's work. In one series of experiments he led his subjects to understand that when the stimulus appeared they were to *construct* any syllable, without thought of the paired associate, so long as it rhymed or was inverted with respect to the *stimulus-word.* Under these instructions there was no tendency for the syllable formerly associated with the stimulus-word to interfere with the reaction; *it was entirely forgotten, although according to the law of frequency it should have been the first to appear.*

Why then did Ach find a conflict? It was because his instructions were to reproduce the associated syllable, rhymed or inverted. His subjects could not follow these instructions without responding in terms of the original configuration, which involved thinking from the stimulus to the associated

[1a] Ach, N., *Ueber den Willensakt und das Temperament.* Leipzig: Quelle and Meyer, 1910.

[2] Lewin, K., "Das Problem der Willensmessung und das Grundgesetz der Association." *Psy. Forsch,* 1922, Vol. 1, 191–302; Vol. 2, 65–141.

syllable before the rhymed or reversed syllable could be constructed. Thus, according to Lewin, *it was the goal, not the number of repetitions, which determined the nature of the reaction in Ach's experiment.*

Wheeler's[3] Study of Choosing. When two goals induce conflicting responses the resulting phenomenon is a *choice.* Wheeler once studied the process of choosing, from the standpoint of the introspectionist; his object was to ascertain what mental processes were involved in choosing. Certain psychologists believed and still believe that introspection abstracts from the process of choosing an elemental and unanalyzable experience which they call, by a circumlocution, a *will-element.* They give to this will-element such names as 'feeling of mental activity,' 'consciousness of action,' and 'consciousness of self-as-willing.' William James named it a 'fiat consciousness.' Wheeler showed, however, that these experiences might be singled out, but in any case were reducible to relatively simple sensory and imaginal processes. Accordingly, *will* as a mental process is not an element or faculty of mind; it is a configuration that can be broken down to processes of a different order. Wheeler discovered, also, that an essential feature of choosing is the making of a *motor adjustment* toward the alternative. When the observer sat completely relaxed *he was unable to choose.* Moreover, so-called motives for choosing are energized choices, just as motivated learning is energized learning. The motive is not a phenomenon separate from the act of making a decision, except as we review the entire performance in retrospect and logically attempt to explain it in a common sense fashion.

The process of choosing, then, can be interpreted in terms of the conditions for least action. The instructions, together with the observer's willingness to co-operate in the experiment, initiate a reaction toward the goal of choosing. This reaction commences in the fore-period as a tension toward either one of two goals imagined by the observer. When the alternatives appear, these two tensions develop further because of additional stimulation, and as a result of being blocked by each

[3] Wheeler, R. H., "An Experimental Investigation of the Process of Choosing." *Uni. of Ore. Pubs.,* 1920, Vol. No. 2.

other, a period of hesitation ensues. The conditions of least action imply that one tension overcomes the other. The vacillation continues until further stimulation in terms of subsidiary verbal or visual responses produces an unequal balance in the tensions; the stronger tension toward one of the goals terminates the choice.

To illustrate, an observer chooses between the two musical selections, 'Miserere from Il Trovatore' and the 'Storm Scene from William Tell.' For the moment he seems inclined to choose either one; the tensions toward either goal are equal. After a period of vacillation he recalls that 'Miserere is vocal.' The discovery that one is vocal and the other not is the stimulus-situation which causes a stronger tension toward Il Trovatore; the goal is reached simply by making the *stronger* reaction toward that title. The same procedure is followed when the subject imagines the alternatives instead of actually looking at the printed titles.

Observational Behavior: Grosser Aspects

Introduction. Up to this time *observing* has been taken for granted for the reason that as yet it has not been isolated from the more complex modes of response in which it occurs. The task now presents itself of limiting the conditions of behavior sufficiently to make these isolations. It will be a study of observational behavior, or in other words, *perception.*

(1) Temporary 'Mental Set' as a Condition of Observation. In Chapter III 'mental set' was discussed as an intellectual habit; indeed, it was observed in a study of social attitudes, wishes and suggestion. It remains to be described in greater detail under more restricted conditions, and its effects upon processes of observing ascertained. Both of these objectives are illustrated in the following incidents.

The author was duck shooting one morning and had hunted for several hours with no success. Obviously he preferred not to return empty handed! As he skirted the edge of the lake, carefully searching each inlet and cove, he suddenly spied a lone duck bobbing up and down on the water some dis-

tance beyond gunshot. Very cautiously he crawled on his hands and knees, always keeping an object between him and the duck, until he was within range. Then he arose to his feet, and taking quick aim, fired. Shot landed all about the target but it failed to move. Surprised, but eager to obtain a second shot before the duck took wing, he rushed toward it, gun poised. Then, just as it seemed about to fly he fired again. His aim was good, but as the splashing quieted down, the duck still sat there as serene as ever. It was a stump! Instances which show the particular twist to any observation furnished by the configuration of the moment could be multiplied without number. Every huntsman knows the danger of shooting too quickly at a moving object in the woods; a deer may turn into another hunter! A squirrel may become the fur cap of a neighbor's boy walking on the other side of the stone fence. The fisherman thinks he has a strike when his hook becomes caught momentarily upon a snag. The nervous autoist mistakes for a newly developed squeak in his car the singing of spring-peepers in the marsh through which he is driving. The timid and superstitious lad returning home after dark along a deserted lane, sees a ghost in the moonlit open space between the trees. Inspect a page of printed text with the idea in mind of finding as quickly as possible the number of times 'will' appears. As a person glances hurriedly over the lines he sees none of the words distinctly until he comes to w-i-l-l. At once these letters stand out with surprising clearness. It seems, in fact, as if they rise up from the page.

(2) **Habitual 'Mental Sets.'** Let a novice enter a lumber yard and attempt to grade timbers according to their excellence of quality and they will all look alike to him. Yet an expert lumber tester will grade each piece as fast as he can write the letter A, B or C upon it. The trained woodsman will hear a faint but significant noise in the thicket, or the distant snapping of a twig, or will see a slight movement on the hillside yonder, any of which the tenderfoot will be unable to detect. The expert pianist listens to a tone and from its quality tells how the key was struck. He knows a dozen or more characteristics which contrast good tones from bad ones,

and it is as easy for him to distinguish the two as it is for the ordinary layman to tell a flute from a cornet. Every expert knows what to observe in his special field; he has developed a specialized insight.

Walk along the street with a blind man. He will tell you correctly that he has just passed by a tree, that now he has come to a fence, now to a building, and now to an open space. Achievements such as these led earlier psychologists to wonder if the blind possessed a special 'sixth' sense. Anyone, however, can accomplish the same feats with a little practice. Nearby objects reflect sounds, cause slight air currents and differences in the temperature of the air. The practiced individual, either seeing or blind, will easily learn to interpret these faint stimulations of the ear and skin correctly. Like the blind, he can develop a permanent 'mental set.'

(3) Change of the Stimulus as a Condition of Observation. The Law of New Insight. Whenever a stimulus-pattern to which a person has become accustomed changes suddenly he becomes alert immediately; the change produces a tension. According to circumstances the tension assumes the form of fear, curiosity, disgust or sudden amusement. In this connection a general law may be formulated that, within the limits of the organism's mental development, *a situation demanding new insight commands its behavior above all else at the time.* For example, any freak or monstrosity claims attention, like a hand with six fingers, a giant, a dwarfish person or a man with long, flowing hair; so too, do all new and striking inventions when they first appear, like the steamboat, locomotive, telephone, airplane and radio.

Seeing people in bathing suits at the beach is to be expected, but should a business man appear in his office, or a student in the classroom dressed in this fashion, onlookers would be astonished. In fact, they would be so poorly adjusted to the situation that they would recoil, horrified, or else give way to unrepressed mirth. If they regard the event as scandalous it is because they are unable readily to see the slightly clad person in relation to the unusual 'setting.' He does not belong to the particular configuration in which he is found. If they regard the event with amusement it is be-

cause of the suddenness with which they perceive the person in new and unanticipated relationships with the total situation. This, in fact, is the circumstance under which jokes are apprehended. And jokes, as everyone knows, always 'claim attention.'

In simpler situations, movement of the stimulus is an outstanding condition of observation. Let a small insect light on one's skin and one fails to notice it until it begins to crawl. A bird in the brush, whose song has attracted attention, becomes visible only when it hops to another branch or starts to fly away. The moving electric sign has become very popular because it satisfies this same condition of observation.

(4) Persistence of the Stimulus as a Condition of Observation. Persistence of the stimulus has opposite effects upon observation according to the relationship which the stimulus sustains to the pattern of which it is a member. Here again, for an explanation, one must fall back upon the principle of configuration. First, a repeated or prolonged stimulus may not be noticed; 'adaptation' sets in. For example, machine-shop workers learn to ignore the din that a visitor would regard as intolerable; the sea-captain accustoms himself to the motion of the boat; tannery employees forget the foul odors around them. In all these cases the stimulus ceases to produce an effect because *it bears no pertinent relationship to the person's activities at the time.* He goes about his specialized tasks noticing only the sounds, objects and odors that are relevant to his pursuits. Second, a stimulus often repeated may be perceived with the greatest readiness. A person may be ever so busy at a particular task yet he will hear the telephone, or his name when someone speaks to him.

The Problem of Repetition and Frequency as Conditions of Observation. Contrary to the popular notion, the frequency of the telephone ring is *not* the condition of hearing it so readily, neither is 'habit of attending' a condition. It is evident, therefore, that the explanation must be found in other conditions, primarily in the fact that the *telephone is part of every stimulus-pattern that functions within the listener's range of hearing.* It sustains a great variety of

relationships in a great variety of stimulus-situations. Here again the law of configuration is seen in operation.

Suppose that an individual is busy in his study, typewriting. He is not only responding to the typewriter but to the room as a whole, a fact which can easily be demonstrated by requiring him to work in some other place. He would then find it more difficult to work. The typewriter is not an isolated object; it is an object that is responded-to in relation to a certain table, and to many other objects about the room. Not only this, but within certain limits the typewriter is responded-to in relationship to the whole house, the extent of isolation of the study, the proper functioning of the heating plant, the peaceful and quiet 'atmosphere' of the house and its 'hominess.' If the individual is unhappy in his home because of uncongenial surroundings even the typewriter plays a rôle according to the character of its setting. Thus, the typewriter and most any other object in the house, including the telephone, may function in the same stimulus-pattern depending upon the complexity of the configuration which the individual constructs in perceiving the object in question.

The constant use of the telephone does not bring it into relationship with the whole house; rather, it is exactly this *insight into the purpose of the telephone which makes the latter an effective stimulus at all times.* If the telephone and the typewriter did not belong to the same configuration, a person would not hear the telephone while working at the typewriter. This conception is borne out by the fact that at times a person fails to hear the telephone although he is well within its range. This is because he limits himself to narrower stimulus-patterns by his attitude and goal. Then it is evident that he is unusually absorbed in his task; he is absent-minded. He fails to respond to immediate stimuli in their relationships to more remote situations. This is not unlike the failure of the novice to hear sounds in the woods. He does not hear them because for him there are no relationships in which they can be heard; he can not construct the goal.

What was just said may appear inconsistent with a widespread practice in advertising, namely, the use of repetition. While repetition of advertisements may be correlated with the

extent to which they attract attention, care should be taken not to assign as a cause the mere fact of repetition. The reader of an advertisement learns more about a commodity when the appearance of advertisements is properly *timed.* Moreover, when repetition involves the appearance of an advertisement in a variety of different places, the observer may be led to think of the commodity in a greater variety of relationships. Accordingly, the appeal of advertisements as far as any single person is concerned is ascribable to factors *attending repetition rather than to repetition per se.* Of course the chief value of repetition in advertising is not alone its effect upon the single individual but the increased chance of its being noticed by a large number of individuals.

The Limits of Perceptual Patterns. It was discovered during a study of the learning process that responses were not based upon discrete elements. This view receives further support from experiments with an instrument known as the *tachistoscope.* The tachistoscope (from the Greek, meaning *quick view*) is a device so constructed that it will expose cards or various objects for brief periods of time through an aperture in a screen. Suppose a certain tachistoscope is set for an exposure time of one fifth of a second, and let a word be exposed on which is printed ten letters arranged in haphazard order. Only five or six letters of the ten will be seen distinctly. However, if a *word* of ten letters is exposed, such as 'experiment,' the word *as a whole* will be apprehended, each of the letters standing out equally within the total configuration. There is *organization* in the second instance and none in the first, hence the difference in range of apprehension.

Observations bearing on this phenomenon go back to the ancients. The Greeks recognized the impossibility of experiencing more than one idea at a time. In 1755, a physiologist, named Bonnet, experimented on the number of discrete 'memories' which he could retain simultaneously. In 1859, Sir William Hamilton called attention to the limited number of objects that could be seen and identified at a single glance. It is possible to classify all of these observations under *attention.* In fact a long line of experimental studies has been made on the *range* or *scope* of attention, and the resulting

facts have been classified under the law: *The range of attention is limited.* But that attention is measured by the range of observation is an assertion which is true or false according to one's definition of attention!

To return to the tachistoscope experiment, suppose an attempt is made under repetition to build up a configuration from disarranged letters. No matter how long the effort, in the end very few if any more can be seen than in the beginning. Even should one be exposed first, then in a second repetition, two, then three, and so on, six or seven would be the limit and these could have been seen as readily at the beginning of the experiment. It is obvious, therefore, that *discrete elements in the form of disarranged letters will not of themselves constitute a configuration.*

Rhythm and Periodicity in Observational Behavior. Very early in the history of psychology the difficulty of holding an idea 'before the mind' for more than a few seconds at a time had attracted considerable notice. This and similar facts have been classified under *fluctuations of attention.* Experimental work on fluctuations began in a systematic way in 1875, with Urbantschitsch, an ear specialist, who noticed that when he tested hearing in his patients there were times within a short period when they could perceive a continuously sounding stimulus of slight intensity and times when the sound was inaudible. Later investigations proved that these fluctuations occurred under a great variety of conditions and in many of the sense departments, but always when the stimulus was barely perceptible. Technically we speak of that point of intensity of the stimulus just above which it is perceptible and just below which it is not perceptible as the *lower limen* or *threshold* of sensitivity.

Look at a very faint point of light in the far distance and it will come and go. Lay a very small object on the skin and after the first few seconds there will alternate a brief period during which the contact will be felt and a period when there will be no sensation. If a white disc, bearing a single radius of small black squares, is rotated in a color mixer there will be seen a series of concentric gray rings that are progressively dimmer toward the periphery of the disc (see Figure 36).

Select the proper ring and fixate it steadily; it will vanish, return, and vanish again. Look at a simple object like a red disc on a gray card. Then, with eyes closed hold a clear-cut visual image of the entire object, and the same fluctuations will be observed. These fluctuations in vision can be controlled to a certain extent by eye-movements. The visual image can be held remarkably well by changing its position and size, because eye-movement, necessary in shifting the image about, furnishes additional stimulation. In case of the gray ring, eye-movement changes the region of stimulation to a fresh place on the retina. All of these examples deal with barely *supra-liminal* 'sensations.'

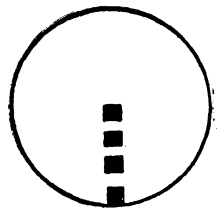


FIG. 36. MASSON DISC.

Guilford's Experiment. Considering the stimulation to remain relatively constant, how are the fluctuations to be explained? Guilford[4] who has suggested a plausible theory, found that the exact point of the limen is indeterminate. There are numerous uncontrolled conditions, all operating together, which determine whether or not the stimulus is perceptible at any one time. A very slight chance variation in these conditions will shift the stimulus to a point above from a point below the limen and *vice versa*. One of these conditions may be fatigue, another may be eye-movement, another may be an actual but very slight change in the intensity of the stimulus, and so on. If it is true that a chance distribution of conditioning factors controls the fluctuations, the liminal stimulus should be perceptible half of the time and imperceptible the other half, and that is practically what Guilford found. Then, by controlling first one possible conditioning factor and then another, especially intensity, he proved that he could shift the stimulus either farther above or farther below the limen as he chose. By so doing he brought the fluctuations under control; he increased the time the stimulus was either perceptible or imperceptible. He concluded that the fluctuations of weak sensations are not to be explained as fluctuations of atten-

[4] Guilford, J. P., "'Fluctuations of Attention' with Weak Visual Stimuli." *Amer. J. Psy.*, 1927, Vol. 38, 534–583.

tion, but are the products of chance variations in the conditions that control the limen.

Selective Character of Configurational Responses. The conditions of configurational responses are so numerous and complex that objects in the environment have unlike effects upon the same individual at different times, and dissimilar effects on different individuals. In other words, the same external situations furnish different stimulus-patterns for different observers and somewhat unlike stimulus-patterns for the same observer on separate occasions. The explanation of these facts can be traced to the constantly varying systems of stresses or potentials within the neuromuscular structures. To begin with, the nervous and muscular systems of no two observers are exactly alike, which means that maturation processes develop in one individual along different lines than in another. Moreover, seldom if ever are there processes induced in like fashion in two persons. Two children in the same family are not subject to precisely the same influences; the attitudes of the family group toward them differ. It happens, therefore, that conditions which will elicit responses in one person will fail to influence another, and that two individuals react differently to apparently the same environmental situations. The term 'attention' has been used to describe the conditions within the observer that account for these differences in reactions, and for the fact that all stimuli do not possess the same value.

To illustrate these general statements, imagine three persons approaching a particular tree along a country road. One of them notices the size of the trunk, the distance between the lowest limbs and the ground, the freedom of the wood from knots and the position in which the tree might be made to fall most easily. The second observer notices the symmetry of the object as a whole, the color and shading of the leaves and trunk, the graceful curves of the limbs and the delicate playing of shadows upon the ground. The third observer notes the density and coolness of its shade, the softness and smoothness of the ground beneath and the attractiveness of the surroundings. Obviously the conditions of observation were strikingly different in these three cases, so different in fact, that with a little thought, the major interests and even the

occupations of the observers can be deduced. The first was probably a lumberman, the second was an artist and the third a camper.

The conditions that give rise to specific responses at any one time are those which arouse the greatest tensions, that is, those which most readily function in the establishing of goals. Other things being equal, situations which affect the autonomic nervous system induce the most demanding tensions—'claim the observer's attention.' The art of advertising makes extensive use of this principle in the selection of themes which will attract the reader. Other outstanding conditions of observation have already been mentioned. The potency of stimuli that possess emotional value was illustrated one day by an instructor in psychology who was lecturing on the conditions of 'attention.' He dropped a handful of coins upon the floor apparently by accident. All of those in the class who had not been listening attentively instantly became alert. In fact two young men in the back of the room who had almost gone asleep awakened with a sudden start!

Origin and History of the Concept of Attention. Recall the statement at the beginning of the text that psychology was once defined as a study of *consciousness.* This definition was to have curious consequences, for no sooner was it formulated when philosophers raised the question: Is it possible to have an idea and not know it; that is, are there *unconscious* ideas? They answered this question in the affirmative. It was in this type of reasoning that the notion of the *subconscious mind* originated in the psychology of the neo-Platonists. A psychic entity, consciousness, was not only assumed, but it was regarded as a quantitative thing exhibiting *degrees* or *levels.* Other questions were subsequently raised; for instance, from what source do ideas come? This was the question which John Locke answered by asserting that ideas traced back to 'sense impressions.' On the Continent this question was answered by making the *opposite* assumption that ideas were innate in the individual. If they were innate where were they before they became conscious? Obviously there must have been a subconscious mind! How, they argued, could any strange object or new idea be apprehended before the individ-

ual acquired any experience by means of which to recognize it? The first element of knowledge in the mental life of the infant must have existed, therefore, in the subconscious mind before it became manifest as a conscious experience. There must have been an unconscious knowing first, in order to explain the conscious recognition of anything. Something could not be derived out of nothing! Perhaps these beginnings of knowledge in the individual were instinctive, or went back to some previous incarnation! At any rate, not realizing that they assumed what they were attempting to explain, the propounders of these theories tried to account for the acquisition of experience in terms of an interaction between the conscious and subconscious minds. *This was the first stage in history of attention-psychology.*

Later forms of this theory assumed that when the senses were stimulated sense impressions developed to a conscious level if there was the proper articulation between them and the subconscious mind. By this time the subconscious mind had been given the name 'apperceptive mass,' and the articulation was construed as an *assimilation* of new *into* old experiences. Thus it was supposedly explained how everything must be apprehended in the light of past experience. Past experience operating in this way upon sense impressions was defined as *apperception* first by Leibnitz (1643–1716) and later by Herbart (1776–1841). *This was the second step in attention-psychology.*

Wundt accepted the notion of apperception and the traditional degrees of consciousness, but discarded the two-level notion of the subconscious and conscious minds and substituted for it the theory of a *single conscious level having a focus and a margin.* While you are reading this text you may be dimly aware, so it is said, of the stuffiness of the room, the hardness of the chair in which you are sitting or of voices in a neighboring room. While the text is the focus, other experiences comprise the margin. *In this substitution, the third step, our modern conception of attention was born.* 'Consciousness' was still supposed to exhibit levels or degrees, but these levels were called *levels of attention.*

Titchener (died 1927), the foremost experimental psycho-

logist of this country, was influenced by this line of development as well as by British Associationism and accepted the traditional level-concept with certain modifications. He construed these as levels of *clearness,* making clearness an attribute or property of consciousness. The author, however, very much doubts the existence of *attributive* levels of clearness. *This concept of attributive levels constituted the fourth and last step in the attention-tradition.*

Attention, like association, was for a long time regarded as an explanatory concept. We fail to hear the telephone because of inattention; the way to vivify an experience or to facilitate its subsequent recall is to give it closest attention; attention is supposed to make the apprehension of objects *clearer.* The literature on attention, alone, runs into thousands of titles, so prominently has it figured in the psychology of the last fifty years. We speak of the range of attention, of fluctuations and inertia of attention, of the muscular adjustments *accompanying* attention, and all of these concepts are direct outgrowths of the supposition of conscious levels. In the meantime Freud revived the notion of levels in its oldest form and popularized the subconscious mind in his famous theory of repressed desires. When a person feels impelled to carry out some act which he ineffectively tries to inhibit, it is proper Freudian psychology to explain it as an expression of a subconscious impulse.

Thus, during the 17th, 18th and 19th centuries there was developing on the Continent a line of psychology quite opposed in its basic assumptions to the parallel development of Associationism in Great Britain. This continental movement may be called *attention psychology.* While Associationism emphasized mental life as a passive condition in the individual, attention psychology made the claim that mental life was dynamic. It was a functional psychology as opposed to Associationism which was structural; the latter emphasized mind as a state, not as an act. But before attention psychology declined, either the subconscious or attention was evoked repeatedly to explain anything about 'mind' which could not easily be explained in any other way. Just as association was for a long time regarded as a condition of learning, attention was regarded as

a condition of observation. In the author's opinion either concept has only a limited scientific use in connection with the elementary phases of psychology. The conditions of association are best described as conditions of learning, and the factors that control 'attention' are the conditions of observation.

We have been studying the conditions of observation in general and were led into a discussion of 'attention.' Next comes a study of specialized modes of observation, such as seeing, hearing, and sensing through touch.

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CHAPTER XIII

OBSERVATIONAL BEHAVIOR: SPACE PERCEPTION

Introduction. There are more refined problems of observational behavior than those discussed in the preceding chapter. These problems have to do with the perception of space, form and movement. Here, for the first time, we are introduced specifically to the sense departments of vision, audition and touch, and are confronted by the more definite and precise conditions that determine the formation of perceptual configurations.

It was work in the psychology of perception in Germany, in 1912 and a few years following, that led to the development of *Gestalt* or configurational psychology. Wertheimer, Koffka, Köhler, Rubin, Korte and Cermak are among those who were prominent in initiating and contributing to this movement, especially Koffka and Köhler. (It was Titchener, in this country, who suggested the translation of *Gestalt* into the term configuration.) These investigators found the conventional theories and assumptions with respect to perception, indeed, with respect to mental processes in general, inadequate to account for the facts. Perception had been defined in terms of the mental elements of sensation and image, which were said to combine according to the laws of attention and association. It had been construed as a relatively discrete and independent process. By independent we mean capable of existing alone, and conditioned by discrete and isolated stimuli. It was assumed that there was practically a one to one relation between a given isolated stimulus and a given isolated mental process, a conception which the *Gestalt* psychologists called the 'constancy hypothesis' and was to them entirely untenable.

The awareness or perception of a single object, say a tree,

in the configurational view, is not conditioned alone by light reflected from the tree to the eye, but by light reflected also from the surroundings. The surroundings constitute a setting which plays an important part in aligning the energy-patterns of the brain in such a way that the tree takes on its 'form.' Thus any perception is a 'structured' phenomenon formed by the interaction of two related systems of stresses, one within the nervous system and one comprising the stimulus-pattern. This 'structure' possesses the property of relative differentiation exhibiting itself as 'figure' and of relative undifferentiation exhibiting itself as 'ground.' (See discussion of figure and ground, page 359.) In other words the image of the tree, formed on the retina by reflected light is not alone sufficient to produce a perception of the tree, as would be the case if the constancy hypothesis were true. Neither would the different colors of the tree or the shapes of different parts of the tree be represented in the nervous system by correspondingly discrete 'blocks' of energy. The details of the perception possess properties by virtue of their relationship to the total perceptual configuration.

What conventional psychology has called sensation and image the *Gestalt* psychology regards as qualities or aspects that, in the development of a given perceptual configuration, have emerged by an individuation process from a relatively undifferentiated 'ground' of experience.

Conditions of Visual Observation

(1) The Conditions of Bidimensional Vision. If the conditions of vision are reduced to their simplest terms by closing the eyes, at once an area of blackness appears before the observer. Analyzing the conditions of this simple phenomenon reveals *first,* that the retina responds in the absence of external light and that this response results in seeing black. It reveals, *second,* that the size of this black area is conditioned by the shape of the retina. If the eyes extended beyond the head, and if the retina, instead of being concave toward the source of light, were convex as is the case with the fly, presumably the extent of the visual field would be much greater.

Third, the apparent size of this area is conditioned by perceiving it in its relation to the total expanse of space about the observer. If the retina were spherical so that the observer could see in every direction at once it is of course highly problematical whether he would have any conception of the total visual field in terms of size. His only conception of size might then be limited to a comparison of objects within the field.

The Localization of Objects in Bidimensional Space. When the observer looks at any object he sees it always in a certain position with respect to the entire visual field. It is directly in front, in the middle of the field, or it is to the right, to the left, above or below the center, and so on. It was formerly thought that localizing an object in space in this way depended upon the fact that each spot on the retina possessed a 'local sign'; it gave rise, when stimulated, to a visual experience in which there was contained *the knowledge of position.* This element of knowledge was called a *spatial quale.* The theory has been abandoned for several reasons. *First,* it seems apparent from observations of child behavior that the child must learn the positions of objects about him. *Second,* unless an object is seen against a background of stationary objects localization is very inaccurate. *Third,* in order to localize an object accurately it must be seen in the center of the field of vision. Objects can not be seen clearly from the 'corner of the eyes' (peripheral vision).

If a person looks fixedly at a chair in front of him he will notice that surrounding objects become more and more blurred toward the limits of the visual field. These facts point to the conclusion that localizing an object in bidimensional space is a matter of learning to construct a perceptual pattern in which the particular object attended-to is seen as a central figure in its relation to surrounding objects. It is quite possible that eye-movements, necessary in bringing an object into the center of the visual field after seeing it in peripheral vision, have something to do with the development of this perceptual pattern. It has been suggested that, in infancy, movements of the arms and body made in reaching for objects aid in the development of this pattern. It is more likely that visual localization of objects develops as a full-fledged per-

ceptual pattern when the neuromuscular mechanisms involved in seeing attain a certain degree of maturity. Should this be true eye-movements may still contribute to the total stimulation necessary in bringing about the spatial effect.

Localization of Objects in Tridimensional Space. The process of seeing objects in tridimensional space is more complicated. Here the list of controlling conditions runs to considerable length; it is customary to classify them in two groups, the physiological and the psychological.

The Physiological Conditions of Depth Perception: *(a) Stereoscopic Vision.* One of the so-called physiological conditions either of observing the depth of objects or their relative distance from the observer is *stereoscopic,* or binocular vision, the fact of seeing the same object at the same time with the two eyes. The eyes of a human being are so placed that light is reflected from a single object to both retinas. This reflected light produces an image upon each retina, *but the images are not exactly alike* owing to the fact that the two eyes converge upon the object from slightly different angles. That is, the right eye sees a little farther around the object to the right than the left eye, and the left eye sees a little farther around the object to the left than the right eye (see Figure 37). Now it happens that light rays, reflected from the object, cross before they reach the retina, so that the image on the retina is reversed as to right and left, and is also inverted. Insofar as both eyes see the same area of the object these retinal images will *correspond;* there will be corresponding points stimulated on each retina. But insofar as the two eyes see different areas of the object the retinal images will not correspond. By studying the diagram one can see just where the *non-corresponding* areas or points lie on each retina. For the right eye they will lie on the side of the reflected image toward the left eye, and for the left eye they will lie on the side of the retinal image toward the right eye. The whole situation may be summarized rather inaccurately by saying that when an object is observed simultaneously with both eyes more of it will be seen than if only one eye were used at a time.

To illustrate these facts, with the left eye closed hold a pencil pointed away from you in front of the right eye in

such fashion that you can not see the point. Without moving the pencil close the right eye and open the left. You can see practically the full length of the pencil, whereas with the right eye you saw only the near end. This illustrates the different views of an object seen with the two eyes. Hold two pencils directly in front of you, one in each hand, one pencil about 10

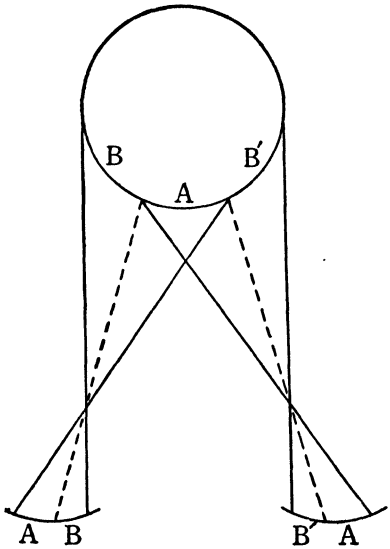


FIG. 37. DIAGRAM ILLUSTRATING STEREOSCOPIC VISION (Schematic).

The circle represents a round object, say a post. Both the left and right eyes see the part marked *A* and the reflected images on the two retinas (*A*, *A*) correspond. The left eye sees *B*, and the right eye sees *B′*; the retinal areas *B* and *B′* do not correspond.

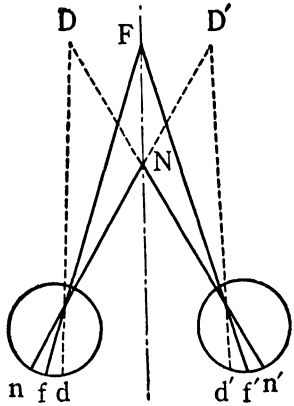


FIG. 38. DIAGRAM DEMONSTRATING THE FORMATION OF IMAGES.

When an object at *N* is fixated, another object at *F* appears to be doubled, the two images appearing in the positions *D* and *D′*. The displacement of the object *F* is traceable to the fact that the retinal images *f* and *f′* are composed of non-corresponding points.

inches away and the other about 18. With both eyes open fixate the nearer pencil carefully, but at the same time notice the *farther* one, which you will see double. Change your fixation to the farther pencil and notice what happens to the *nearer* one. This time you see *it* double. In this way you have demonstrated what happens when the reflected images fail to correspond because of the sharp angle with which your eyes were converged (see Figure 38). The assertion can now be understood that seeing the depth of an object is a mid-

way stage between seeing an object single and seeing it double. If there are no non-corresponding points, as would be the case in seeing an object with only one eye, perception of depth is not complete. If there are slightly too many non-corresponding points compared with corresponding points, the object is seen partly doubled; if there are no corresponding points two complete images of the same object are seen.

In 1838, Wheatstone invented an apparatus called the *stereoscope,* with which it was possible to combine the view of an object as seen with one eye with the view of an object as seen with the other. He used mirrors which reflected the views of both objects simultaneously upon both eyes; the result was a most striking illusion of depth. In 1850, Brewster invented a refracting stereoscope, which by means of prism-lenses, superimposed a picture as seen with one eye upon a picture of the same object as seen by the other eye. This is the ordinary household stereoscope so commonly seen in homes a generation or so ago. The pictures to be superimposed are drawn upon a stereoscopic slide whose distance from the eyes can be adjusted to the observer's vision. It is a simple matter, however, to obtain stereoscopic effects without the use of lenses. See the discussions of 'free' stereoscopy in the literature.[1]

Retinal Rivalry and Binocular Color Mixture. The extent to which retinal disparity (corresponding and non-corresponding points) controls depth perception can not be ascertained, for there are many other factors operating along with it. Certain of these additional factors become evident in experiments on retinal rivalry. If two different colors are superimposed in a stereoscope, they will oscillate. Part of one color gives way to part of the other color; and at times the figure takes on a translucent appearance. If the colors are black and white, a peculiar luster or 'graphite-like polish' may be seen instead of the black or the white. If two differently colored drawings are properly selected as to quality and intensity there is said to be a mixing of the two colors although certain investigators have doubted this observation. These

[1] Titchener, E. B., *Experimental Psychology.* New York: Macmillan, 1909, Vol. 1, pt. 1, 137 ff; and Vol. 1, pt. 2, 261–269.

facts would indicate that *retinal images are subordinate to the total situation of two retinas and a brain.* That is, disparate images have no part to play as isolated factors in conditioning visual depth, but only as they belong to a total and unified pattern of conditioning factors.

This assumption is confirmed when in a stereoscope one looks at a white line on a black background with the left eye, and at a white surface with the right eye; *the white line still appears distinct from the white background.* According to the theory of corresponding points one would expect to see the line fuse into the white surface, since the points covered by the line in one eye correspond to points covered by the white surface in the other. Evidently the white line stands out by virtue of its position on the black surface; it is a part of the perceptual configuration seen by the left eye and owes its existence quite as much to the background of black as to the fact that it furnishes its own stimulation to the retina.[2] Moreover, part of a figure seen with the left eye and part of a figure seen with the right eye can be made to combine stereoscopically into one figure, while the other part of the original figures can be made to combine into another single figure. The two figures can be also seen in different planes. Again, if a row of three dots is exposed to the right eye and a similar row of three dots exposed to the left eye, the two sets of dots superimposed, conditions can be set up in which a displacement of an end dot in one of the figures tilts the line as seen by both eyes combined.[3] And finally, it is possible to arrange experimental conditions so that two colors may be seen, the one behind the other. Indeed, by arranging mirrors in certain ways a double stimulation of the same spot on the retina results in the appearance of one object lying behind the other.

Inversion of the Retinal Image. It was said above that the retinal image is inverted. Ordinarily the observer does not notice that he sees everything upside down but conditions can be so controlled as to make the inversion very striking.

[2] Lau, E., "Versuche über das stereoskopische Sehen." *Psy. Forsch.,* Vol. 2, 1923, 1–4; 1924, Vol. 6, 121–126.

[3] Lewin and Sakuma, "Die Sehrrictung monokularer binokularer Okjekte." *Psy. Forsch.,* 1924, Vol. 6, 298 ff.

Stratton [4] once performed a classical experiment in which for days he wore *lenses* (pseudoscope) that made everything look upside down. After wearing them for a time objects began to right themselves and eventually everything had returned to normal. Then he removed the glasses, whereupon all objects appeared inverted, and gradually there was a second orientation back to normal.

Physiological Conditions of Depth Perception. (*b*) *Eye Movements: Convergence.* Each eye is supplied with six external muscles whose combined action rotates it with the least expenditure of muscular energy. Donders, a Dutch oculist, was the first to discover this principle in connection with the resting eye; Listing then applied the same principle to the rotating eye. The principle of least action as applied by these investigators may be summarized as follows: Under ordinary circumstances, no matter whether the eye is at rest, or moving, there is always such an equilibrium of tension that the eyes undergo a minimum of torsion.

One of the common forms of eye movement is *convergence,* which is the second so-called physiological condition of depth perception. Upon fixating *near* objects the eyes converge as a consequence of which a certain amount of strain is felt, whereas on fixating distant objects the two lines of regard are practically parallel and little if any strain sensations are noticeable. It has been thought that differences in strains of convergence helped in perceiving visual objects as lying a given distance from the observer, since the amount of eye-strain is inversely as the distance of the object. However, if the factor of convergence is singled out and employed it will not, alone, guarantee a judgment of distance.

(*c*) *Accommodation.* When a single eye is focused upon distant objects the muscle of accommodation inside the eye is at rest, but when a near object is focused the muscle of accommodation contracts. That strains and relaxations of this muscle figure in the perception of depth has been questioned, but it is probably one of many contributing factors.

(*d*) *Binocular Parallax.* We have already seen that the

[4] Stratton, G. M., "Vision Without Inversion of the Retinal Image." *Psy. Rev.,* Vol. 4, 1897, 341, 463.

two eyes obtain slightly different views of the same object. If the object is close to the face this difference is relatively greater than if the object is farther removed. Accordingly, as the observer backs away from an object, or as the object moves from the observer, the relative number of non-corresponding points *decreases.* The displacement of views is known as *binocular parallax;* changing it conditions visual depth perceptions.

(*c*) *Monocular Parallax.* As you ride along in an automobile and fixate a spot midway between you and the horizon, objects beyond your fixation point move in a forward direction and objects between you and the fixation point move to the rear. In each case the apparent rate of movement is proportional to the distance between the object and your point of fixation. The same phenomenon can be observed when you move your head rapidly to and fro while at the same time you fixate an object midway between you and the farthest point of vision. The relative displacement of objects with reference to the fixation point is known as *monocular parallax.*

Psychological Factors. In addition to these physiological factors are several so-called psychological conditions of depth perception. These are the conditions employed in painting and drawing in order to produce illusions of perspective and distance on a flat surface. The *first* of these is *size of the retinal image.* An object near the eye, other things being equal, throws a larger image upon the retina than if it were farther away. The smaller this image the greater the apparent distance to the object. Notice, for example, how small a house appears in the distance compared with its size when only a few feet away. *Second,* there is geometric or *linear perspective,* for example the apparent convergence of the rails when one looks down a railroad track, or the apparently smaller size of the far end of a building as compared with its nearer end. *Third,* there is *aërial perspective,* the change in apparent color and distinctness of outline as one looks from near to far objects. *Fourth,* is *light and shadow.* High lights indicate protruding surfaces and shadows indicate receding surfaces. *Fifth,* is *interposition.* When one object partly covers another the first is seen as nearer. *Sixth,* is the *position of objects on the ground plane.* Objects lying on the ground close to the ob-

server are seen as lower down than objects on the ground some distance away. The ground plane rises as the observer shifts his regard toward the horizon, the position of objects in the ground plane indicating their distance from the observer.

Illusions and Hallucinations. By a proper control of the conditions of observation it is possible to produce a misperception of an object, or an *illusion.* As a rule an illusion is determined by peculiar arrangements of external stimuli. When the conditions of observation are dominated largely by factors *within the organism* the misperception becomes extreme; then the illusion is an *hallucination.* For example, the victim of *delirium tremens* may see snakes. Presumably the only external condition of an extreme 'misperception' of this kind might be the inherent light of the retina. It is a common fact of observation that by pressing upon the eyeballs vivid colors and wierd shapes can be seen floating in space close to the observer's head. In extreme alcoholism there is perhaps an exaggeration of this retinal phenomenon caused by increased blood pressure. Then, depending upon the subject's mood or mental set at any given time, he misperceives these retinal lights. Other hallucinations are illustrated by the religious fanatic who, pursued by the idea that he must reform the world, mistakes his own verbal imagery for the voice of God. Another fanatic transforms a cloud into an angel descending from Heaven and forthwith claims to have visions. It occasionally happens that an external stimulus is misperceived in the same way by an entire group of individuals. An instance of this sort was reported at the front during the World War when large numbers of soldiers agreed that on several occaions they had seen the Christ. The external stimulus was a peculiar growth in the limbs of a tree; troops in the vicinity who were doubtless praying to the Christ for protection saw this contour of limbs in terms of their 'mental set.' Experiences like these might be repeated over and over without discovery of the external cause, hence the apparent genuineness of the apparitions.

Visual Illusions. We said that visual illusions can be produced by controlling the conditions of observation. These conditions are satisfied by grouping lines and figures in various

ways with respect to each other. There result so many kinds of illusions that it will be impossible to discuss more than a few typical examples. In a first group may be included illusions of *reversible perspective*, typified by the falling cubes of Figure 39.

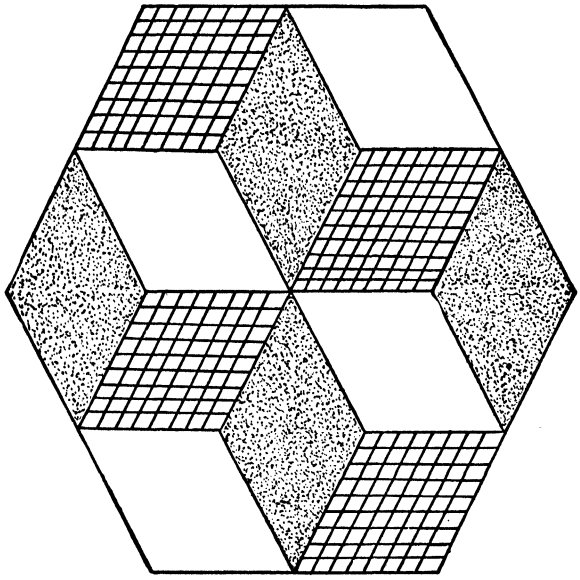


FIG. 39. THE 'FALLING CUBE' ILLUSION OF REVERSIBLE PERSPECTIVE

Conventional psychology would explain this illusion in terms of eye-movement. Fixate the middle line of a cube, move the eyes outward and its back is seen. Fixate an outer line of a given cube, move the eyes inward and the cube reverses. The fixated point appears nearer. While eye-movement is undoubtedly one condition of the illusion it is obvious that if the cubes were not *arranged* to make a configuration possible, there would be no illusion. In a *second* group may be included *illusions of extent* like the famous Müller-Lyer arrow (Figure 40). The theories advanced to explain this type of illusion have been many and varied. It can not be explained in terms of any one single factor

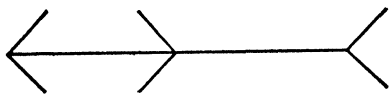


FIG. 40. THE MÜLLER-LYER ILLUSION.

such as opened spaces to the left and closed spaces to the right, or a prolonging of eye-movement on the left and a checking of it on the right because of the short oblique lines. Rather, the illusion is conditioned by the total arrangement of the lines, various single factors contributing by virtue of their relationship to the whole.

Third, there are reversible *figure and ground illusions,* as in Figure 41. Notice that either a vase or two faces may be seen. The part of the total visual object seen as vase or as faces is called a *figure.* The figure is sometimes regarded as



FIG. 41. REVERSIBLE FIGURE AND GROUND ILLUSION (Rubin).

that feature of a perceptual pattern to which the individual 'attends,' or in other words the feature which 'stands out.' In conventional language this figure would be in the focus of attention and the ground would be the margin. But the configurationists deny that figure and ground can be described in terms of 'attention,' because attention refers to degrees of clearness, and according to the configurationists the concept of clearness does not apply to figure and ground. Rather, figure and ground are equally 'clear' but they differ in degree of differentiation, and the reversals are shifts in the organization of contour lines into different configurations. The organized pattern of lines becomes the figure; the rest becomes ground.

The example well illustrates the configurational principle as it applies to perception. Every perception is a figure-upon-a-ground, and the ground has quite as much to do with the existence of the figure as do the stimuli which produce the figure. The figure exists by virtue of its relation to the ground. To consider another example, look at a row of pictures on the wall. The spaces between the pictures, together with the sur-

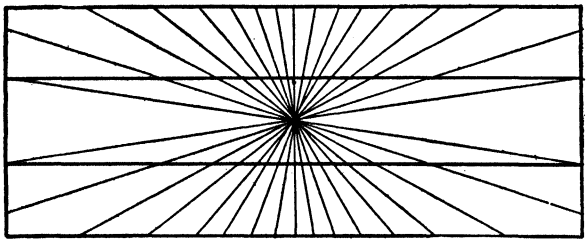


FIG. 42. THE HERING PARALLEL LINE ILLUSION.

rounding wall, constitute the ground; this ground is very important in 'bringing out' the pictures. According to the configurational theory the total perception is not constructed by adding the retinal image of one picture to the retinal image of another, and then adding all these to the retinal image of the background. It depends upon a response of the retina as a whole to a differentiated stimulus-pattern as a whole. The



FIG. 43. SLANTING SEGMENTS OF THE PARALLEL LINES OF THE HERING FIGURE AS THEY SHOULD BE SEEN IN TERMS OF THE CONVENTIONAL THEORY.

phrase, *figure-ground,* is intended to convey the meaning that the pictures are not perceptions separate from the ground but are figures appearing upon it, the total figure-ground phenomenon being the perception.

Fourth, there are many illusions of direction, as in Figure 42. To explain the Hering figure earlier investigators assumed that the obtuse angles are underestimated and the acute angles overestimated, thus producing an apparent displacement of the parallel lines. When, however, the conditions of this theory

are satisfied there should be seen, not a pair of parallel lines which bulge in the center, but parallel lines made up of short oblique strips as in Figure 43. Underestimating each acute angle will not, through summation, explain the total effect of the figure, for the sides of the angles are straight lines and by no stretch of the imagination can curved lines be summated from straight ones! (Koffka.) This illustrates the general principle that the whole can not be derived from its abstracted parts. What produces the illusion, evidently, is the effect of the figure as a whole. Perhaps the radii suggest a *circle,* in which case the parallel lines assume a curvature to fit into the configuration.

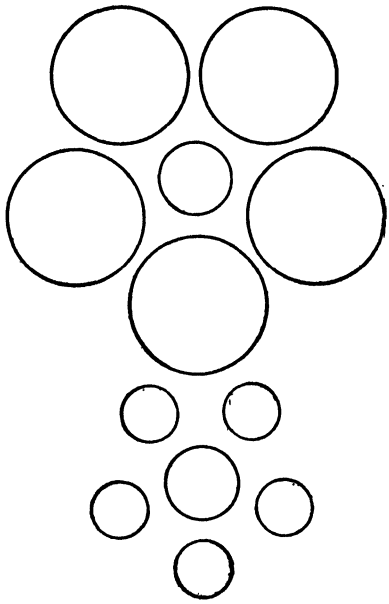


FIG. 44. ILLUSION OF SIZE.
The inside circle below appears larger than the inner circle above, but both are the same size.

Fifth, there are *illusions of area or size.* Figure 44 illustrates this group. Note that the character of the ground upon which we see a figure determines the character of the figure.

VISUAL PERCEPTION OF MOVEMENT

Wertheimer's Experiment. In 1912, Wertheimer[5] published the results of an extended research on the perception of movement, an investigation which was influential in the development of the configurational hypothesis. Briefly, his results were as follows: If two slits are made in a screen, as shown in Figure 45 and each slit is momentarily illuminated from behind, *the observer sees neither slit of light* provided

[5] Wertheimer, M., "Experimentelle Studien über das Sehen von Bewegung." *Zeit. f. Psy.,* 1912, Vol. 61, 161–265.

the illumination in each case is of the proper duration and the time interval between the two exposures is adequately controlled. Instead, he sees a light moving from the position of the first slit to the position of the second. If the time interval between exposures is too short he sees two stationary slits simultaneously. If the time interval is too long he sees first one illuminated slit and then the other. Under the conditions of this simple experiment it is possible to establish definite laws of optimum movement. This was done by Korte,[6] whose laws are as follows:



FIG. 45. SLITS FOR DEMONSTRATION OF APPARENT MOVEMENT.

Korte's Laws. 1. *Spatial separation varies directly with intensity,* that is, for optimum movement the distance between the stimuli must be proportional to their intensity. If the space interval between the stimuli is increased, optimum movement is lost unless the intensity of the stimuli is also increased.

2. *Intensity varies inversely with the temporal interval.* If the intensity of the stimuli is too great, movement will not appear until the distance between them is increased. It will also appear when the time of exposure of the stimuli is decreased. If the time of exposure of each stimulus is too long, movement appears when the time interval between the stimuli is increased, and when the intensity of the stimuli is decreased.

3. *Temporal interval varies directly with spatial separation.* For optimum movement the distance between the stimuli must be proportional to the time interval between exposures. If the space interval is increased the time interval between exposures must be lengthened.

A movement seen under the conditions just described and reduced to its simplest terms, is called the *phi phenomenon.* Full, optimum movement of the kind produced in Wertheimer's experiment is precisely the basis of the moving picture illusion, and the method of producing the illusion in moving pictures is essentially similar to the experimental method. A momentary exposure of objects in one position is

[6] Korte, A., and Koffka, K., "Kinematoskopische Untersuchungen." *Beiträge z. Psy. d. Gestalt,* 1919.

followed by a like exposure of the same objects in a slightly different position. As a result, continuous movement is seen instead of stationary objects.

Varieties of Apparent Movement. By varying the conditions under which apparent movement takes place it is possible to obtain different varieties of the phenomenon. (1) *Alpha movement* is seen when the apparent size of an object changes, as when the central lines of the Müller-Lyer figure grow longer or shorter depending upon the position of the oblique lines. (2) If a figure of a certain size is exposed to the observer briefly and at the proper time interval a similar but larger figure is exposed, the original figure grows in size; if the reverse conditions obtain the figure diminishes. This is called *beta movement.* (3) If a weaker stimulus, for example a slit of light, is exposed first and another but stronger slit of light is then exposed at the proper time interval, movement is seen from the second to the first stimulus and then back to the second again. In other words, movement takes place in the reverse direction from the spatial order of the stimuli and then toward the position of the stronger. This, which is called *delta movement,* involves a striking instance of movement in the line of least action; energy evidently flows from the more strongly stimulated section of the brain to the more weakly stimulated area. (4) It frequently happens that a figure will expand as it is exposed and contract as it disappears. This is called *gamma movement.*

Apparent Movement a Configurational Phenomenon. How is apparent movement to be explained? Conventional psychology attempted to account for it on the basis of after-imagery on the retina. That is, an after effect of one exposure was supposed to last until the next exposure appeared. The overlapping of temporal relations was said to have produced a continuity of effect. But this theory failed to take into account the obvious *spatial gap* between the two exposures. Because of this gap there seems to be no way of explaining apparent movement as a retinal phenomenon. Moreover apparent movement set up under the conditions of Wertheimer's experiment can not under certain conditions be distinguished from actual movement. It is obvious, therefore,

that actual movement and illusions of movement are similar under certain conditions, and that both are to be explained by a reference to the brain. Wertheimer, Köhler[7] and others have offered substitute physiological explanations, too complicated to go into here in detail. Suffice it to say that two images are formed on the retina by the two slits. One set of nerve fibers connects one of these images with one region of the brain and another set of fibers connects the other image with another region. In this way the stimulated spots on the retina are *projected* on the brain. When each of these regions is stimulated there is a flow of energy from either one in the direction of the other, causing the perception of movement. Notice that no movement is seen until the second stimulus is exposed. The result is a unified, total reaction to a total situation, the situation being two exposed slits on a background. The unified reaction is a perception of movement. The reaction is also directional in that a remote end determines what happens; one part of the brain is stimulated first, but a perception will not occur until there is a subsequent stimulation of another part of the brain. In other words no brain action takes place until an 'end' is established or an area exists of low potential.

In the perception of actual movement there is evidently to be found a limiting case of the conditions for apparent movement. In the former case an object stimulates one retinal area, then an adjacent area immediately afterward, the temporal and spatial conditions being adequate for the perception of movement. But DeSilva[8] finds that the outstanding condition for real movement is velocity and that the conditions for apparent movement are different, namely, spatial separation of the stimuli and the intensity of the stimulus. His observations indicate that the two kinds of movements differ qualitatively. As a consequence he believes that the two phenomena are to be accounted for on the basis of different rather than similar principles. It is probably true, nevertheless, that while the configurational substitutes for older theories of movement

[7] Cf. Helson, H., "The Psychology of Gestalt." *Amer. J. of Psy.*, Vol. 36, 1925, 514 ff.

[8] DeSilva, H. R., "An Analysis of the Visual Perception of Movement." *Brit. J. of Psy.*, January, 1929.

have yet to be worked out in detail, they will prove more adequate than the older theories.

Miscellaneous Forms of Observational Behavior

Conditions of Making Auditory Observations. We observe with ears as well as eyes. What, then, are the conditions of observation in the field of hearing? Just as in vision objects are localized in space and are seen in motion, so in hearing, sounds are localized, and under the right conditions are perceived as moving. A *first* condition of sound localization is the fact of *binaural hearing.* A sound coming from the right is heard with slightly different intensities and with slightly different qualities by the two ears. A *second* condition may be movement of the head or body in the direction of the sound. A curious phenomenon occurs when the sound comes from a plane midway between the two ears. Under these conditions, if ideal, the quality of the sound heard in each ear is the same; its intensity is also the same, and muscular movements in one direction are inclined to be as strong as movements in another. As a consequence very striking errors are made in trying to locate the sound; a sound directly over the observer's head may be heard at his feet, or behind him. *Third,* sounds which come from a distance have lost a certain amount of their intensity. The distance of the sound from the observer is judged partly in terms of this factor. *Fourth,* the quality of sound varies as the distance for the reason that overtones drop out, making a distant sound seem thinner. Thus a voice heard in the distance, especially a voice singing, sounds phonographic.

As in the case of visual space perception, auditory space perception is not a product of any of these as separate agencies, although when they are controlled, one by one, the observer's localization of the sound is affected. Hearing a localized sound, then, is a perceptual configuration and each of the factors just discussed plays a part in the total stimulus-pattern.

The following facts bear out this statement: (1) If two sounds are of different pitch or quality, one heard from the right and the other from the left, they are localized separately;

but if the two sounds are alike except for intensity, they are usually heard as only one and on the side of the greater intensity. Now if, in addition, they are alike in intensity, they seem to come from the median plane between the two ears. (2) Hum a low note with closed lips, place a palm of the hand tightly over one ear and the sound will be localized in that ear. Ordinarily the humming sound appears to come from the middle of the head. Supposedly, these observations can be explained by the fact that the bones of the head conduct sounds from the throat to the ears, and closing one ear produces a greater resonance in that region of the head.

Phase Difference as a Condition of Sound Localization. Recent experiments [9] have indicated that phase differences in the sound waves at the two ears condition localization when the sound is a tone. By phase is meant the position of the displaced particles in the vibrating medium (generally air) with reference to their position before displacement. Roughly it means the trough or crest of the wave. A single tone, as 'pure' as can be produced, is conducted by means of tubes to each ear. When one tube is made slightly shorter than the other the phase of the tone in one ear is advanced over that in the other without altering the intensity, that is, the crest of a sound wave will reach one ear ahead of the corresponding crest approaching the other ear. Under these conditions the sound is localized on the side of the advancing phase. Curious effects are produced by the appropriate control of these phase differences; the subject hears secondary or 'phantom sounds' floating in the space above him.

Banister,[10] who has done extensive work in audition, especially in connection with sound localization, concludes that phase differences do not condition localization. He argues that a certain amount of bone conduction is necessary to account for changes of localization with variations in phase, and finds, from experiment, that sound conduction does not affect hearing in the ear that receives the stimulus last. Other in-

[9] Halverson, H. M., "Binaural Localization of Tones as Dependent upon Differences of Phase and Intensity." *Amer. J. Psy.*, 1922, Vol. 33, 178–212.

[10] Banister, H., "Phase Effect and the Localization of Sound." *Phil. Mag.*, 1926 (VII), Vol. 2, 402–431.

vestigators, working with noises instead of pure tones, find that very slight time differences in the reception of the noise by the two ears affects localization. It is a simple matter to demonstrate that intensity differences in the two ears condition localization, when phase is controlled. The exact relationship and relative importance of these various factors remain to be ascertained.

Auditory Movement. In 1917 Burtt[11] was able to produce auditory illusions corresponding to apparent visual movement. His apparatus consisted of a time-controlling mechanism and three telephone receivers connected in series with a 250 vibration tuning fork. One receiver was mounted on an arm that moved synchronously with the timing mechanism; the other two receivers were stationary. The sound emitted from the receivers was produced by the tuning fork. His method enabled him to produce either a moving sound or one of similar intensity and quality heard in two successive positions. He found that two faint, similar auditory stimuli presented in quick succession a few centimeters apart gave the impression of a sound moving in the direction of the actual temporal sequence of the stimuli. Under the conditions of his experiment a time interval between 25 and 30 thousandths of a second gave optimum movement. He claimed to have verified Korte's laws, for sound. The longer the exposure of a given sound the shorter the optimum time interval. When the second stimulus was louder than the first, movement took place in the reverse direction as in vision. These results should be verified because it is possible that the auditory movement was partly if not largely a matter of visualizing the sounds.

Localization of Sound with Ears Reversed. Young[12] has performed some very interesting experiments in audition corresponding to Stratton's experiments in vision. With specially constructed ear-trumpets it was possible to turn into the right ear sounds that came from the left of the observer and *vice versa*. While wearing these trumpets Young found that

[11] Burtt, Harold, "Auditory Illusions of Movement: A Preliminary Study." *J. Exp. Psy.*, 1917, Vol. 2, 63–75.

[12] Young, P. T., "Auditory Localization with Acoustical Transposition of the Ears." *J. of Exp. Psy.*, 1928, Vol. 11, 399–430.

orientation to environmental sounds was reversed. On approaching a street intersection he heard an automobile apparently coming from the right, but on looking down the street there was no machine to be seen; it was coming from the left. Imagine talking with a person sitting on one's left and hearing him as if he were the person on one's right! As was the case with vision, after wearing the trumpets for some time there took place a re-orientation which had to be reversed when the phones were removed.

Tactual Configurations: Localization of Tactual Sensations. We observe also by means of touch. When an observer is stimulated on the back of the right hand he has no difficulty in stating instantly *where* the contact was made. Thus the problem of localization arises again, as in vision and hearing.

The Two-point Threshold. E. H. Weber, about 1840, discovered that if two points are pressed against the skin, the distance at which they must be separated to be perceived as two instead of one *varies for different parts of the body.* Two points, a millimeter apart, can be felt on the tip of the tongue, but on the middle of the back points less than sixty-eight millimeters apart (about two and one half inches) will usually be judged as one.

Weber's figures for different parts of the body are as follows, translated into millimeters. They are called measurements of the *two-point threshold.*

TABLE IX

TWO-POINT LIMENS

	Mm.
Tip of tongue	1
Tip of finger	2
Red part of lips	5
Under middle joint of finger	7
Cheek	11
Back of the hand	31
Forearm, lower leg	40
Cervical region of the back	54
Middle of the back	68

Weber's Circles. The apparatus resembling a drawing compass, used in experimental work upon the two-point sensi-

tivity of the skin, is called an *aesthesiometer.* Suppose that one point of an aesthesiometer is pressed repeatedly upon the same spot on the skin while the other point is rotated around the position of the first as an axis. A zone can be ascertained anywhere within which the two points are felt as one and outside of which they are felt as two. This zone will be elliptical, and shorter in a transverse direction than in a direction parallel to the body or limbs. (Weber's ellipses or circles.)

Vierordt's Law. Vierordt[13] formulated a law pertaining to the two-point threshold, that *fineness of the sense of locality increases directly as the distance of that area from the axes about which it may be rotated.* For example, the arm rotates about a point in the shoulder as an axis, therefore, the nearer the tips of the fingers the *finer* the two-point threshold.

A phenomenon comparable with the two-point threshold appears when an observer attempts to locate, with the point of a stylus, the exact spot on the skin just previously touched, the observer blindfolded. He will make an error of localization roughly proportional to the two-point threshold of that region of the body.

Theories of the Two-point Threshold. Theories of the two-point threshold fall into two groups, the first assuming a special distribution of nerve connections to the skin, the other basing the phenomenon upon muscular movement. The former has little factual material to support it; the latter rests upon the fact that the most sensitive regions of the body are the most mobile, hence the two-point configuration is refined in proportion to the complexity and delicacy of exploratory and manipulatory movements.

The two-point threshold is a factor in the finer attempts at localizing. It is only a minor factor in those tactual configurations that involve the whole body. The grosser activity of locating a contact against the cheek, as opposed to the neck, body or foot has never been adequately explained. As in the case of vision, 'local signs' have been posited, but the more plausible conception supposes a tactual configuration of the body as a whole to form during infancy and early childhood with the

[13] Cf. Ladd and Woodworth, *Elements of Physiological Psychology,* 1911, 398.

maturation of the nervous system and with the aid of exploratory movements and vision.

Tactual Illusions of Movement. A year after Wertheimer published his epoch-making work on visual apparent movement Benussi (1913) found a similar phenomenon in the field of touch. Since then there have been several investigations of touch, all based upon Benussi's method. He used an apparatus which is called a *kinohapt,* a device for applying point-contacts against the observer's skin under conditions that control intensity of impact, duration of impact and time intervals between stimulation. With an instrument of this kind, Burtt [14] was able to verify the laws of movement as worked out by Korte for vision. He also found the same reversal of movement when the second stimulus was more intense than the first.

Methods of Measuring Observational Behavior

Weber's Law and Just Noticeable Differences. Around 1830, while experimenting upon the sensitivity of the skin, Weber found that the least noticeable differences between the *feels* of different weights did not correspond to actual differences in the values of the weights themselves. He discovered that the relationship between these 'feels' and the actual weights could be expressed in terms of a law as follows: In order to produce least noticeable differences in stimuli, the stimuli must be altered by a constant fraction. Suppose a 30 gram weight is used first, then another weight compared with it will be judged equal unless it differs by a certain fraction of thirty, say 1/30th of 1 gram. If a 300 gram weight is used, before the comparison weight will be judged lighter or heavier it must also differ by 1/30th, or in this case, 10 grams. The difference between the feel of one weight and the feel of a weight just perceptibly heavier or lighter illustrates a *just noticeable difference* (J. N. D.). Just noticeable differences deal generally with intensities of sense-perceptions. Weber's Law can now be stated, after Fechner, in more precise lan-

[14] Burtt, H., "Tactual Illusions of Movement." *J. Exp. Psy.,* 1917, Vol. 2, 371–385.

guage: To obtain a series of just noticeable differences (an arithmetical progression of intensities) the stimuli must progress by a constant fraction (geometrical progression). In other words, the sensation is proportional to the logarithm of the stimulus ($S = C \log R.$). The magnitude of the fraction depends upon the particular sense department with which one is dealing. For vision it is about 1/100; for sound, 1/3; for smell, 1/4; for kinaesthesis, 1/40; and for pressure, 1/15. The law holds for certain of the sense departments but only in the middle range of intensities, not for the entire range. Moreover, the fraction is quite likely to vary along the range; there is some evidence that it becomes smaller and then larger as one goes from lower to higher intensities.

Applications of Weber's Law. If a room is lighted first by a single candle and then by another, the difference in illumination is obvious, but if the room is illuminated originally by a 100 candle power lamp, adding a single candle makes no appreciable or at least only a barely appreciable difference in the brightness of the light. To make his voice audible to individuals sitting in the front of an auditorium a lecturer speaks with moderate loudness, but to enable listeners sitting farther and farther back to hear with equivalent distinctness he must speak relatively louder and louder. This means that a difference of a few rows toward the rear of an auditorium changes the audibleness of sounds relatively more than the same number of rows nearer the front.

The Psychometric Methods. The procedures are very complicated by means of which the finer measurements of observational behavior are made. Only a few of the standard methods for computing just noticeable differences (*difference limens*) will be described here. First, there is the *method of just noticeable differences.* To begin with, two stimuli of equal intensity are used, such as two lights, one a standard and the other a comparison light. One of them is made more intense by slow degrees until it is judged brighter. The amount of change is measured in physical units, as in candle power or Watts, or photons. Then the comparison light is made obviously brighter than the standard and moved toward it in intensity until the two are judged equal. The average of these

two types of determinations is a measure of the just noticeable difference.

Second, there is the *method of average error.* Here again there are two stimuli, a comparison and a standard, the standard being constant in intensity throughout. The comparison stimulus, for example a light, is always changed from an intensity that is appreciably different to an intensity that seems equal to the standard. There will nearly always be an error of judgment, for the lights will be judged equal before they reach physical equality or not until afterward. This procedure yields a measure of the variations which occur in a comparison stimulus before it appears different from the standard. The average error of several judgments is the threshold value.

A third method is called the *method of constant stimuli.* Several comparison and several standard stimuli are used none of which is adjustable. Suppose weights constitute the stimuli, the standard of which is 100 grams. Comparison weights varying systematically certain amounts from it, for example, 92, 96, 104 and 108 grams, are then compared with the standard. When the 100 and 108 gram weights are compared most of the judgments will be correct; there will be a few instances in which the weights will appear equal and perhaps a very occasional instance in which the 108 will seem lighter than the 100. The proportion of wrong judgments will be much greater with the weights 100 and 104. Finally there will be a certain kind of chance distribution of the judgments equal, lighter and heavier, when two 100 gram weights are used. The difference limens can be measured by analyzing the distribution of judgments mathematically, a procedure which involves comparing the results at different parts of the intensity range.

The 'Phi Gamma Hypothesis.' The greater the difference between the standard and comparison weights the greater the extent to which the conditions are under control that determine the judgment. When a 108 gram weight and a 100 gram weight are used the difference of 8 grams is sufficient to offset most of the chance factors which might cause a judgment 'lighter' or 'equal.' When a weight of 92 grams is compared with a weight of 100 grams the difference of 8 grams is sufficient to guarantee fairly constant judgments of

'lighter.' But when weights of 96 and 100 grams are used the smaller difference exerts less influence so that a larger proportion of wrong judgments can be expected. Among these wrong judgments there will be a greater number of 'equal' than of 'heavier.' When two weights of 100 grams are compared a great many times, conditions will arise that lead to several judgments of 'lighter' and 'heavier' although a majority of 'equal' judgments is to be expected. With weights of 100 and

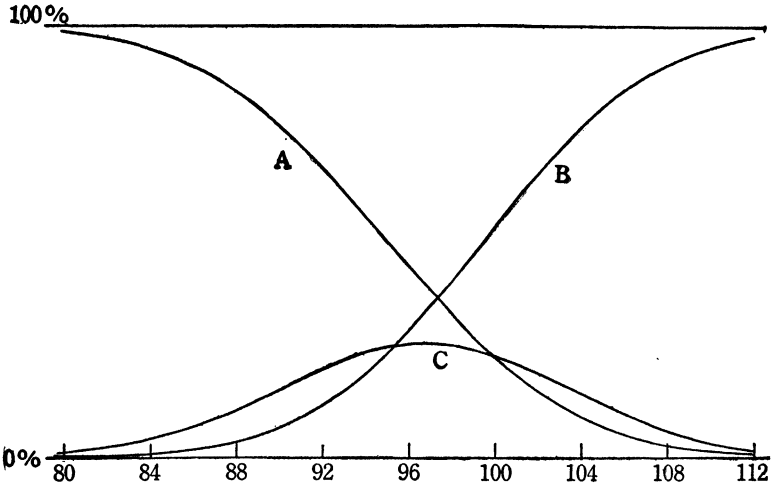


FIG. 46. THEORETICAL CURVE ILLUSTRATING THE PHI GAMMA HYPOTHESIS (Urban).

Fitted to actual data from lifted weights by Urban, *Psy. Rev.*, 1910, Vol. 17, 229. 80, 84, 88, *etc.*, are the values of the weights in grams. *A* is the curve for the judgments 'lighter'; *B* is the corresponding curve for the judgments 'heavier'; *C* is the curve for the equality judgments. The ordinates of the three curves at any given weight sum to 100.

104 there will occur a few cases of the judgment 'lighter' and almost none in case of the 100 and 108. From the one extreme of difference to the other there is a systematic *decrease* in the proportion of judgments 'lighter.' Conversely, there is a systematic *increase* in the judgments 'heavier.' It is presumed that this systematic decrease of 'lighter' judgments and increase of 'heavier' judgments can be predicted by cumulative curves of distribution. That is, the curves measure the increasing probability of 'lighter' judgments as the comparison

weights become lighter and the increasing probability of 'heavier' judgments as the comparison weights become heavier. It is presumed, further, that the distribution of equality judgments plotted against the same pairs of weights can be predicted by the normal probability curve. These suppositions are known as the *'phi gamma hypothesis.'* Figure 46 shows typical theoretical curves which actual experimental data more or less approximate. They are known as curves of the *psychometric functions.* Thurstone [15] has shown recently that the psychometric curves are not exact phi gamma curves, describable by the integral of the normal probability curve.

So much for the psychophysical methods in general. We may consider one example of an experimental study based upon a typical method.

Heymans' Law of Inhibition. By introducing inhibitory or counter stimuli, Heymans found evidence, in 1899, that the threshold value of a given visual stimulus was raised to an extent proportional to the intensity of the inhibitory stimulus. Recently Spencer and Cohen [16] have extended the data to include the case where the original or inducing stimulus falls upon one eye and the inhibitory stimulus falls upon the other. It appears, therefore, as if the threshold for one stimulus was at any time a function of the intensity of inhibiting influences in the external and intra-organic environment of the observer. This fact can be stated in configurational terms as follows: Whether at any one moment a certain liminal stimulus will be perceived depends upon the character of the total pattern or sensory stimulation at the time, not alone upon the absolute intensity of the liminal stimulus. In other words, the limen is determined by the configuration of the moment, and intensity is an important factor. The fact that the inducing and inhibiting stimuli can be given to separate eyes again suggests the fact that the brain always functions as a whole.

[15] Thurstone, L. L., "The Phi Gamma Hypothesis." *J. Exp. Psy.*, 1928, Vol. 11, 293–305.

[16] Spencer and Cohen, "The Concept of the Threshold and Heymans' Law of Inhibition I." *J. Exp. Psy.*, 1928, Vol. 11, 88–90; II. Same *J.* 1928, Vol. 11, 194–201.

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CHAPTER XIV

OBSERVATIONAL BEHAVIOR: FINER ASPECTS. VISION AND HEARING

Introduction

In our study of the human being he has been seeing, hearing and feeling, first, in social situations, second, in problem situations which defined his behavior as intelligent, third, in conflict situations which define his behavior as emotive, fourth, in situations repeated at given intervals which defined his behavior as learning, and finally, in situations limited to a single object or group of objects which were merely observed. Throughout we have been restricting the conditions of behavior little by little and as a consequence we have been studying simpler and simpler activities.

In the present and following chapters we shall study observational behavior stripped to its lowest terms and taking place under the simplest possible conditions. This means that measurements will be relatively exact and predictions relatively certain. The particular features of this behavior which we shall isolate for special study are called *sensory processes.* They are relatively simple perceptual configurations. The conditions under which sensory processes occur are roughly of two kinds: (1) conditions pertaining to the external stimuli, which we shall now regard as isolated physical forces, and (2) conditions having to do with the specialized nerve structures of the sense organs acted upon by the external stimulus.

Classification of External Stimuli. From a physical standpoint stimuli are vibratory phenomena of varying wave-lengths. Those of longest wave-length are perceived as mechanical impacts through the sense of touch. Those of shortest wave-length are called electrical, whose vibration fre-

quency far exceeds that of light. Table X shows the relationship of certain of these physical stimuli to each other.

TABLE X

CLASSIFICATION OF PHYSICAL STIMULI[1]

Physical Process	Wave length	Number of vibrations per second	Receptor	Sensation
mechanical contact	.....	very slow to 1550 per second	skin	pressure
waves in 'material' media	12,300 mm. to 13 mm.	30 per second to 40,000 per second	ear	tone
? waves	.1 mm. to .0004 mm.	3000 billion to 800,000 billion	skin	warmth heat
	.0008 mm. to .0004 mm.	400,000 billion to 800,000 billion	retina	light color

Classification of Receptors. The receptors or sense organs of the body are generally divided into two main groups, the *somatic* and *visceral.* The somatic group includes, *first,* the exteroceptors (source of stimulation external) of which there are several kinds: (a) organs of vision, the rods and cones of the retina, (b) the organs of hearing, the hair cells in the inner ear, (c) organs of pain, free nerve endings, (d) organs of warmth of an unknown character, (e) organs of cold of an unknown character, (f) organs of pressure, structures at the roots of the hairs, encapsulated end-organs in the skin, Pacinian, Merkel's and Meissner's corpuscles (?). The somatic group includes, *second,* the *proprioceptors* (the source of stimulation internal in the form of muscular contraction and movement of the joints). There are, (a) end-organs of tendon sensibility within the tendons, tendon corpuscles, (b) organs of muscle sensibility in the muscles, muscle spindles, (c) organs of joint sensibility, the Pacinian corpuscles that lie in the surfaces of the joints, and (d) organs of static and equilibratory sensibility in the organ of equilibrium.

The visceral group contains, *first,* a specialized sub-group including taste buds in the tongue and organs of smell in the

[1] Cf., Herrick, C. J., *Introduction to Neurology.* 2d ed. 1920, 77.

nasal passages. There is a *second* and more general sub-group which includes organs of hunger in the stomach wall (?), organs of thirst in the pharyngeal mucous membranes, organs of pain located in the internal musculature and linings of the body, organs of distension of cavities like the stomach, rectum and bladder and organs giving rise to sexual sensations.

The Function of Sense Organs in General. Probably no conscious behavior takes place in the adult organism without the functioning of a certain portion of its receptors. As we shall see later, evidence from a study of living embryos suggests that the body moves under the influence of its own nervous system before functioning sense organs develop, but the developed nervous system probably at all times functions as a complete unit.

Each type of sense organ is so specialized in its structure that certain forms of vibrations will act upon it to a maximum degree and other forms to a minimum degree, if at all. Accordingly, Sherrington formulated a law to the effect that the main function of the receptor is to lower the threshold of excitability of the nervous system for one kind of stimulus and to heighten it for all others. In other words, the receptor 'selects' by its response to it, a certain force among the numerous kinds that are always impinging upon the organism. The kind of force or stimulus which ordinarily elicits a response from a given receptor is called an *adequate stimulus.*

The Law of Specific Nerve Energy. Should there be more than one kind of stimulation that produces a response in a particular sense organ, the response, presumably, will always be of the same type. If the retina is stimulated by light, by electricity, or by pressure, the effect will always be the same; the organism will see light or color. If free nerve endings in the skin are stimulated by excessive heat, by chemicals, by extreme pressure or by electric currents, the response is always pain. The fact that a highly differentiated sense organ always responds the same way, regardless of the method of stimulation, is known as the *specificity of response.* This specificity of response led Johannes Müller, a pioneer nerve physiologist, to formulate *the law of specific nerve energy* which assumes that the type of nerve impulse set up by any given receptor

is always the same. Helmholtz made the law a little more definite by assuming a specific type of nerve current for every distinct 'quality' of sensory process, even within one sense department. For example, in vision there are numerous color qualities to be accounted for like red, green and blue. The validity of these speculations has never been definitely proved or disproved.

Vision

The Visual Stimulus. The visual stimulus is supposedly an electro-magnetic wave, transverse in character, giving rise always to degrees of white and black or of colored light. A wave of light is a very complex process composed in some unknown way of waves of different lengths which, if segregated, produce the spectral colors. The wave-lengths for the different spectral colors are as follows:

TABLE XI

WAVE-LENGTHS OF SPECTRAL COLORS

	Millionths of a millimeter (millimicrons)
Limit of visible spectrum at violet end, about..	390
Range of violet.....	390–422
wave-length best representing the color....	410
Range of blue.....	422–492
wave-length best representing the color....	470
Range of green	492–535
wave-length best representing the color....	520
Maximum visual intensity about.....	535
Range of yellow	535–586
best yellow	580
Orange, range of	586–647
best orange	600
Red, range of	647–810
best red	650
Limit of spectrum at red end.....	810

It will be noticed that the long wave-lengths fall at the red end of the spectrum and the short wave-lengths at the violet end.

Complexity of Light as a Condition of Vision. That the complexity of light is a condition of certain specific visual phenomena is apparent from the fact, *first,* that unanalyzed

(white) light produces a class of visual processes having the common features of *brightness* and ranging, according to the energy of the light, from black to white through a series of grays. This series is called the *achromatic* series of visual sensations. *Second,* where white light is disintegrated by a prism there appears a band of monochromatic lights, each light having a wave-length of its own. Moreover, in breaking up white light, certain pigments reflect monochromatic or simple mixtures of monochromatic light. For example, in the case of a green leaf the differences with which the pigment transmits various wave-lengths result in an absorption of all colors except green and to some extent yellow; the latter two colors are reflected. The pigment in red cloth reflects chiefly the wave-lengths for red and absorbs the others, and so on. The visual phenomena produced by monochromatic forms of light are called colors, and constitute the *chromatic* series of visual sensations, namely, the spectral colors and their mixtures.

Wave-length as a Condition of Vision. The fact that different colors can be seen as the wave-length of monochromatic light is varied means that wave-length is a condition of vision. It conditions the quality of the color or in other words its *hue,* the blueness of blue, greenness of green, and so on. But it likewise conditions *brightness* for as one wave-length is substituted for another the colors shift in their brightness. Yellow, for instance, is the brightest color of the spectrum and violet is the darkest in normal daylight illumination, with the eye adapted to light.

Energy of Light as the Condition of Vision. Every one has noticed the disappearance of colors during a sunset and their appearance during a sunrise. Observation reveals a certain order in which the spectral colors fade as the energy of the light is reduced. The yellows fade first, then the reds, then the blues and at last the greens. This means that in twilight vision green is the brightest color as opposed to yellow, which under ordinary conditions is the brightest color in daylight vision. This shift in the relative brightness of colors with a reduction in the energy of the spectrum is known as the *Purkinje phenomenon* after its discoverer. It is demonstrable in daylight by looking at a pattern of colors through a pinhole

in a screen. It has just been indicated that when the energy of the spectrum is sufficiently decreased *colors turn gray.* When the spectrum is greatly increased colors likewise lose their hue and approach white light.

Interrelation of Color Phenomena. Take a red disc and whirl it around rapidly; it is a red of considerable *saturation,* a rich, concentrated red. Suppose a little white is added; the red will then become lighter; it will be a *tint* of red, and at the same time will become less saturated, for as white is added the concentration of the red is reduced. Now a medium gray instead of white can be added to the red, in which case the red becomes neither lighter nor darker but merely less saturated as it approaches gray. Black could be added and darker and darker *shades* of red obtained, also at the sacrifice of saturation.

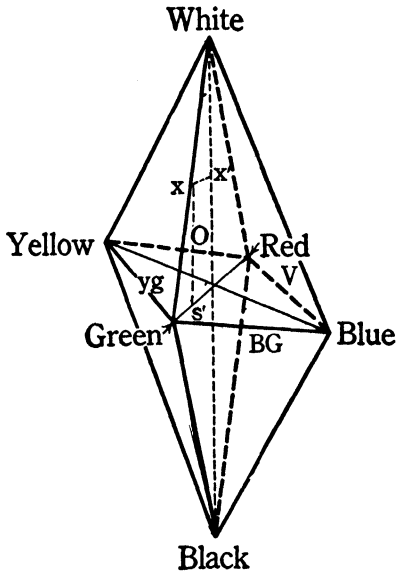


FIG. 47. COLOR PYRAMID.
Modified after Titchener, *Textbook of Psychology,* Macmillan, 1913.

The interrelationships of these qualitative features of color vision can be pictured in the form of a pyramid (Figure 47), with a square as a base, the corners of the square representing the four so-called elemental colors of the spectrum: red, green, yellow and blue. The various hues of the color series are represented at their maximum saturation around the edge of the square. The middle point of the square represents a 'neutral gray' midway between black and white. This approximates the gray that, as will become evident shortly, is seen when complementary colors are mixed. A straight line across the square connects the positions of complementary colors. The edge of the pyramid, Blue-white, represents the number of dis-

tinguishable tints of blue from pure saturation to pure white; Green-white represents the same thing for green, and so on. The outer surface of the upper pyramid, then, represents all distinguishable tints. Below the square, the corresponding surface represents all distinguishable shades. A straight line from white to black represents all possible shades of gray, ranging from pure white to pure black, through a medium gray.

For practice, let the point X on the pyramid be interpreted. X is a point representing a light green, about half way between saturated green and pure white. If the hue is subtracted from the light green a gray would remain of a brightness corresponding to X′, a gray midway between white and medium gray. With the color X to start with, if the same amount of green is retained but white subtracted, a gray-green would be left, represented by the point S′. Thus, all points along a line parallel with the vertical axis of the pyramid, such as X — S′, represent equal amounts of saturation. Any horizontal plane running through the pyramid parallel with the base represents different hues of similar tint or shade. When the pyramid is cut from any point on the outside to a corresponding point upon the axis a series of colors is laid bare of the same hue and tint but of varying saturation.

Refracting Media of the Eye as Conditions of Vision. Light reaches the sensitive region of the eye through four refracting media: (1) the cornea, (2) the aqueous humor, a watery fluid lying in a chamber between the cornea and the lens, (3) the crystalline lens and (4) the vitreous humor, a transparent and homogeneous gelatine-like substance filling the main cavity of the eyeball. These four media bend or refract the light rays to a surface approximately 20 millimeters behind the cornea where the retina lies (see Figure 48).

In the normal eye, refracting media thus bring the light rays to a focus upon the retina. But when the eyeball is too long, or the refracting curvatures too great, rays come to focus before they reach the retina; this condition is known as *myopia,* or near-sightedness. If the eyeball is too short, or the refracting surfaces of too gradual a curvature, the rays are not

focused by the time they reach the retina; this condition is *hypermetropia,* or far-sightedness. In either case the image is blurred and a correction can be made by means of lenses external to the eye. In the normal eye the refracting surfaces are so curved as to be sections of true spheres all meridians of which are of equal curvature. In many eyes the curvatures of different meridians differ, producing a defect in vision known as common *astigmatism,* which can also be corrected with lenses.

Accommodation. Accommodation is the process of changing the curvature of the lens so that light rays are refracted more sharply to a focus as the observer looks at near objects. The distance at which the eye is barely able to accommodate is called the *near point.* At 10 years of age this point lies at an average distance of 2.76 inches from the eyes; at 20 it is 3.94; at thirty, 5.61; at forty, 8.66; at fifty, 15.75, and at sixty, 39.37. This rapid receding of the near point in old age is probably caused by a stiffening of the lens as a result of which near objects are blurred, especially reading material; this condition is known as old-sightedness or *presbyopia.* (Howell.)

The far point of clear vision with the accommodated eye ranges from 20 to 30 feet; beyond that distance light rays are sufficiently parallel to permit a focusing upon the retina without muscular effort on the part of the eye. Hence, in distance vision the eye is at rest. In a resting eye the *ciliary muscle* is relaxed; the ligaments between the muscle and the lens are tightly stretched, and the lens is pulled into a relatively flattened position. Rays that are relatively parallel, coming from distant objects, will then be focused upon the retina. When the observer looks at objects within 20 to 30 feet the ciliary muscle contracts, pulls forward the choroid coat, lessens the distance between the wall of the eye and the lens and loosens the ligaments; the elastic lens then bulges of its own accord, altering especially the front curvature (Helmholtz). As a result, converging light rays are more sharply refracted making it possible to see near objects distinctly.

Retinal Factors as Conditions of Vision: (1) *Rods and Cones.* The retina forms an inner layer or coat covering

approximately the posterior two-thirds of the eyeball. Light refracted to it filters through *the retina* to specialized receptors, the rods and cones, which *face away from the source of light.* These structures derive their names from their shape.

The rods and cones are not uniformly distributed over the retina. There is a central region immediately behind the lens composed almost exclusively of cones; this is the spot of clearest vision, the *fovea centralis.* At the fovea, cones have an average diameter of three microns (a micron is one-thousandth of a millimeter), an average length of eighty-five microns, and are very closely packed together. On the nasal side of each retina and slightly above the fovea is a region called the *optic disc,* a supposed *blind spot,* the region from which nerve fibers of the entire retina leave the eye and form the optic nerve. It has always been thought that this region possesses no rods and cones. Toward the margin of the retina the cones become less thickly distributed until finally only rods are left. Because one sees less well in the dark with his fovea and better with the margins of his retina, and since under ordinary conditions the margins of the retina are color-blind, the cones are said to be organs of color (and brightness) vision while the rods are organs of brightness vision alone. This is the duplicity theory of von Kries; it is supported by the fact that the retinas of nocturnal animals have few if any cones.

Retinal Factors: (2) *The Blind Spot.* It has been assumed for a long time that at the point of exit of the optic nerve from the retina there are no sensitive mechanisms. Recent work by Koffka and especially by Helson [2] throws much doubt upon this long accepted view. Helson found in very carefully controlled experiments that his observers could see with the blind spot. Practically in no instance could they see the form of objects but they could see color, and in certain instances more than one color at a time. His results indicated either that there are receptors stretched across the blind spot or that the fibers of the optic nerve are themselves sensi-

[2] Stern, A., and Koffka, K., "Die Wahrnehmung von Bewegungen in der Gegend des blinden Flecks." *Psy. Forsch.,* Vol. 7, 1926, 1. See also *Brit. J. of Psy.,* Vol. 15, 1924, 269; Helson, *Amer. J. Psy.* 1929, Vol. 41.

tive to brightness and color but hardly to form. If the latter is true the chief function of the rods and cones, according to Helson, is probably that of furnishing detail of outline and form; they prevent *diffusion* of the stimulus effect. Vision in the blind spot is diffuse; color from a stimulus of small dimensions is seen over a wide area of the visual field. In terms of Helson's theory, the nerve fibers are incapable of preventing diffusion owing to their relative lack of specialization of structure.

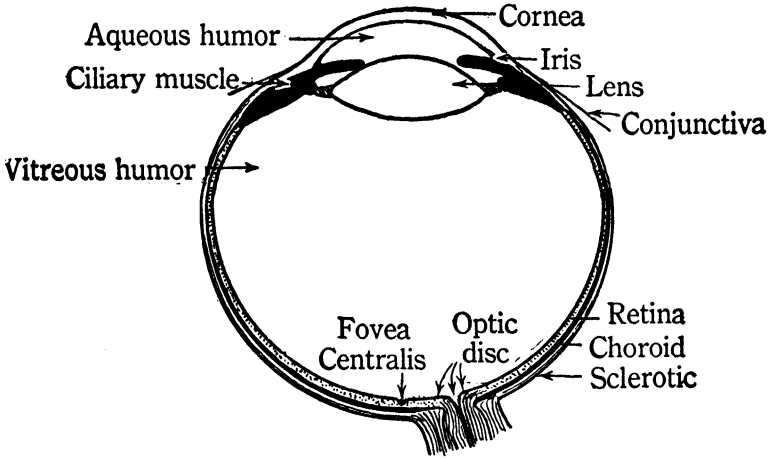


FIG. 48. CROSS-SECTION OF THE LEFT EYE.
The terms choroid and sclerotic refer to coats of the retina.

Retinal Factors: (3) *Retinal Zones.* The view that the retina is sharply zoned with regard to its color sensitivity is another exploded tradition. Under normal conditions of illumination a certain kind of red stimulus will change to gray when shifted gradually from the middle of the visual field toward the periphery. A selected green will also change to gray in approximately the same place. This fact led many to assume that a red-green photochemical substance that was responsible for red-green vision existed in the center of the retina. Beyond the limits of the red-green zone there was supposed to be no red-green substance, hence the retina was color-blind to red and green beyond that limit. Similarly, move a yellow stimulus from the center of the visual field to

the periphery and it will be seen until it reaches a point somewhat beyond the limit for red and green, at which it changes to gray; blue also changes in about the same region. Hering would lead us to assume that a yellow-blue photochemical substance was distributed over a somewhat larger area of the retina. Beyond the limits of this yellow-blue zone the retina is still sensitive to black and white; hence, according to Hering the entire retina is a black-white zone containing a photochemical material called the black-white substance.

Recent experimentation by Feree, Rand and others [3] shows that when the intensity of the stimulus is increased the limits of these so-called zones *approach the periphery of the retina.* Accordingly, if there are three photochemical substances, as Hering thought, their distribution is over the entire retina, or nearly so. It is a better guess that intensity of stimulation, along with distribution of chemical substances, is the condition under which the zones appear. Moreover, work on large numbers of observers raises a doubt whether the red and green zones are normally of the same size.

Color-blindness. The whole problem is complicated further by facts of color-blindness. A person who is completely color-blind to green is generally color-blind to red also; a person blind to more colors than red and green is generally color-blind to both yellow and blue. Hering implied that red-green color-blind persons lacked the red-green zone and that totally color-blind persons possessed only the black-white zone. But the facts are too complicated to be classified by a simple scheme of zones.

Wave-length, not a pairing of colors, is the important factor in color-blindness. Some individuals are more color-blind to red than to green; they do not respond to the longest wave-lengths of the spectrum. In certain cases there may be a loss of sensitivity to red, not a complete loss to green and a partial impairment of blue and yellow vision, indicating that the threshold of color sensitivity is increased for the entire spectrum. In these persons the range of the visible spectrum is shorter

[3] "Further Studies in the Extent and Scope of the Color Fields in Relation to the Intensity of the Stimulus Effect." *Amer. J. of Physiol. Optics,* Vol. 5, 1924, 409–419.

than normal and the spectrum itself shows less color. In the most common form of color-blindness sensitivity is evidently confined to two wave-lengths, yellow in the first half of the spectrum and blue in the second half. Between yellow and blue is a band of gray; in the place of red there is faint yellow and for violet there is a faint blue.

Color-blindness was first studied systematically in the late seventeen hundreds by Dalton, a color-blind chemist. In 1878, a Swedish physiologist, Holmgren, invented a test for color-blindness with the use of colored wools and showed by his test how to avoid railroad and steamship accidents caused by employees who could not distinguish colored signals. Investigators have found that from 2 to 4 per cent of men were color-blind and less than 1 per cent of women, but color-blindness in men is probably a little higher than these early investigations indicated.

Duration of the Stimulus as a Condition of Vision: (1) *Adaptation.* Immediately after stimulation of the retina either by white or by colored light, there sets in a process called *adaptation.* When an observer first enters a dimly lighted room nothing is visible, but after a few seconds have elapsed he begins to distinguish objects. Similarly, upon coming out of a dark room into brilliant illumination he can not see clearly until he has become adapted.

Wearing colored glasses is an excellent method of demonstrating adaptation. When the observer first looks about him, with red glasses on, everything is shaded red; gradually the color diminishes in saturation until objects approach their natural appearance. Another demonstration can be made with an apparatus as in Figure 49. Fixate the center of the figure; as time goes on the black becomes lighter and the white looks darker until the whole figure takes on practically the same brightness. A green and red figure of the same pattern would approach gray. From facts like these it is possible to formulate the law of adaptation, that all *sensations of color tend toward neutrality (gray) and sensations of light toward a middle gray.* The question may be asked, When we see so much color in nature, especially green, why do we not become adapted to it? There are several reasons, of which one is the

fact that the colors are not sufficiently saturated or intense. Moreover, we are constantly shifting our gaze and consequently prolonged stimulation of one spot on the retina by a single color seldom occurs.

(2) *Contrast.* Under certain conditions adaptation leads to the phenomenon of *contrast.* The inky blackness of a room upon entering it from the light and the dazzling brilliance of light upon coming out of a dark room are examples; remove the red glasses mentioned in the preceding paragraph and for a short time everything looks green. Look steadily at a red

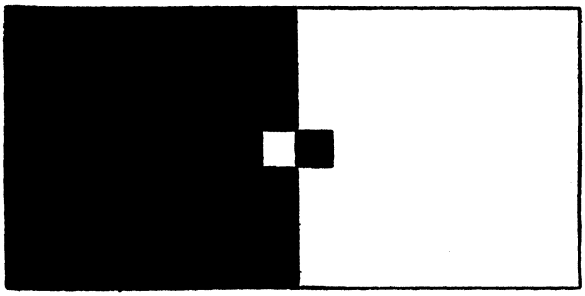


FIG. 49. ADAPTATION APPARATUS.

surface with a gray center and the center will eventually take on a tinge of green as adaptation to red takes place. The same phenomenon is seen in green shadows from red light, yellow shadows from blue light, and so on.

(3) *Negative After-imagery.* Under certain conditions contrast effects appear as *negative after-images.* For example, fixate Figure 49 for at least sixty seconds, then look at a plain white surface; the complement of the figure will be seen as a *negative after-image.* Look steadily at a square of red paper for sixty seconds, then at a light gray or white surface and there appears a green after-image; blue gives a yellow after-image and so on. Look momentarily at a brilliant light like the sun or a mazda lamp and there will follow a series of colored after-images alternating by complementaries, known as Fechner's flight of colors.

(4) *Positive After-images.* When a fairly bright visual

stimulus is suddenly removed there is noticeable a momentary positive after-effect, an after-image of the same quality as the stimulus; as it fades it passes over into a negative after-image. Look at a window, then close the eyes quickly; for an instant the bright light of the window seems to remain in vision, then it changes to a greenish or reddish negative after-image.

The Laws of Visual Contrast. Experiments on contrast have yielded the following laws: (1) The contrast-effect is always in the direction of greatest qualitative opposition; it is the greatest when the two colors are complementaries and least when they are nearest alike. Thus the complementaries, yellow and blue, give good contrast-effects while yellow and orange yield almost no contrast.

(2) The nearer together the contrasting surfaces the greater is the contrast-effect; the effect is greatest along the edges of two contrasting areas. A small area within a larger one suffers from contrast much more than a large area in the same relative position.

(3) The contrast-effect is enhanced by the elimination of contours or boundary lines. Place tissue paper over a red square with a gray center and the center will look greener than if its contours had not been eliminated. This law is applied in obtaining contrast-effects on the stage by using finely netted curtains.

(4) The contrast-effect is proportional to the saturation of the inducing color. A saturated red, for example, produces more contrast toward green than does a weak red.

(5) Color contrast is greatest when there is no simultaneous light contrast (Titchener).

Rapid Successive Stimulation of Identical Retinal Areas as a Condition of Vision: (1) Flicker. *Talbot's law.* Suppose a disc is made of two colors, red and green. As long as the disc is stationary, part of it is seen as red and part of it as green for each part stimulates different areas on the retina. Rotate the disc slowly; one part of the retina is being stimulated with green light before it is through responding to the red light. The effect is a coarse flicker, but as the disc is rotated a little faster, the flicker becomes finer; finally, with a sufficiently rapid rotation of the disc the flicker disappears

entirely and a fusion of the two colors occurs. There is a law pertaining to the brightness of this fusion and all other fusions similarly obtained. *The brightness of the fused sensation is equal to the total brightness of the individual stimuli if we imagine the brightness of each individual stimulus to be spread uniformly over the entire area affected.* This law is named after its propounder, W. H. F. Talbot, one of the inventors of photography.

Flicker is a very useful phenomenon in measuring the brightness of colors and in comparing the brightness of colors and grays. Suppose a person wanted to compare the brightness of a certain red with a gray. A semicircle of the color and one of the gray are fitted together to make a circular field; in front of this field is rotated a disc composed of alternate open and closed sectors. If flicker is abolished in the two halves of the field at the same time, the two are of equal brightness; if the flicker disappears from the color first, the color is less bright than the gray. By varying either the color or the gray, samples can be found which will be equal in brightness. The instrument used in measuring the relative brightness of colors is called the *flicker photometer,* one modification of the *episcotister.*

If a white sector is very slowly turned upon a black ground in a color wheel, a series of radiating black bands can be seen on that part of the white surface which first stimulates the eye; these are called *Charpentier's bands* after the name of their first observer. Revolve the apparatus a little faster under good illumination and various colors appear on the white surface, known as *Fechner's colors.* The causes of these phenomena are still a matter of conjecture.

Evidence of the Configurational Hypothesis from the Facts of Fusion. An interesting configurational phenomenon can be demonstrated in connection with fusion. Rotate a white disc bearing a wide, black band as in Figure 50 (A). Since the proportion of white to black increases toward the margin one might expect that the gray mixture would appear brighter in that direction. On the contrary the whole field is a uniform gray with the exception of a small area near the center of the circle of the same width as the

band. Split the band into several pieces of black, as in case of the Masson disc (Figure 36), and one sees concentric rings that become whiter toward the margin. The uniform area observed in case of the continuous band bears out the view that the whole is not the summation of its parts. If parts suffice to explain wholes, the ratio of black to white at any point along the radius would lead one to suppose that the resulting gray would be different from the gray at any other point, and that the whole would be an aggregation of varying shades of gray. Moreover, the stimulation of the retina *is exactly this;* the actual proportion of black to white *does vary* all the way from the center to the margin of the stimulated area. But the observed effect is a *surface of homogeneous* gray; it is evident, therefore, that the retina is not the exclusive controlling factor.

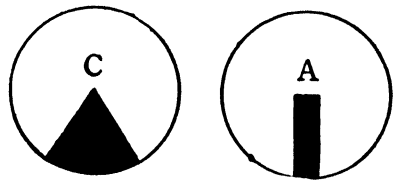


FIG. 50. DISCS FOR DEMONSTRATING FUSION.

When disc *A* is whirled rapidly a uniform gray surface is seen. The same fact holds for disc *C*.

It may be supposed in this case that differential stimulation of the retina is changed over in the nervous system so that the ultimate response represents an equal distribution of energy within the limits of the areas that are functioning. The gradual gradient from darker to lighter gray across the whirling disc plays a part in producing the homogeneous effect. This gradient is not sufficient to produce a differential stimulation of the retinal structures (rods and cones), as a consequence of which they all respond to the same extent. Notice that when the black radius is broken by white squares as in the case of the Masson disc, the outer rings of gray are lighter. The retinal structures stimulated by the edges of the squares function as limiting membranes that prevent a diffusion of the stimulus effect over the engaged part of the retinas, or else prevent a diffusion in the brain. If the homogeneous effect depends upon diffusion, this phenomenon illustrates the conditions of least action. Just as gas in a container will diffuse until it exerts equal pressure on all sides, so the

retinal or brain energy involved in responding to the rotated disc diffuses equally in all directions over the affected area, thus resulting in a homogeneous appearance of the disc. The response is the simplest possible one under the existing conditions.

Successive Stimulation of Retinal Areas as a Condition of Vision: (2) Laws of Color Mixture. The earlier work on fusion led to the formulation of three well known laws: (a) For every color there is a complementary which, if mixed with it on the retina in the right proportions, produces a brightness, and if mixed in any other proportion will give a color of low saturation and of the hue of the stronger component. The complementaries are spectral red and bluish green, orange and violet, yellow and blue, spectral green and bluish red, purple and greenish yellow. (b) A mixture of any two colors which are not complementaries produces a color of intermediate hue; for example, red and yellow give orange. (c) If two color mixtures produce the same color or brightness, a mixture of these mixtures will yield a similar product; a red and green that will produce a gray, and a yellow and blue that will produce a gray, will all cancel out to gray, when mixed.

Cermak's Parallel Laws. Recent experimentation has brought the facts of mixture and fusion into relation with the facts of apparent movement. We have seen that movement is produced by two stimuli of appropriate duration, accurately controlled with respect to space and time intervals. Suppose these three conditions of apparent movement are varied all in proportion; that is, suppose we reduce the time interval between exposures practically to zero, eliminate the space interval and reduce the time interval almost to zero, but repeat the intervals very rapidly. We still have the conditions of apparent movement, although we may regard this example as a limiting case. But these are also the conditions of fusion. Accordingly, Cermak has propounded a set of *parallel laws* which hold for light mixtures as well as for apparent movement.

1. Light intensity varies inversely as the time of exposure.
2. Lessening the time of exposure favors the fusion.

3. Changing the time of dark exposure influences fusion and movement more than does changing the period of illumination.
4. The greater the time of exposure the less must be the interval between exposures.
5. Reducing the size of the object favors fusion.
6. Central foveal vision favors fusion.
7. Except for very weak intensities dark adaptation favors fusion.
8. Up to a certain limit lengthening the period of illumination hinders fusion.

If the underlying physiological processes are similar for the seeing of color quality and also for the seeing of movement Cermak has made one of the most important discoveries in modern psychology.[4] Quality as such has always been an unsatisfactory phenomenon to deal with by scientific methods; no one understood what sort of a phenomenon it was; no one knew how to classify it. Cermak places it in the category of space-time configurations; it is governed by the same laws as govern perceptions of movement, of form, and of distance. By quality, of course, is meant the unique and differentiating characteristics of a sense experience, as the color qualities, tone qualities, pressure, pain, smell qualities and the like.

Configuration as a Condition of Vision: (1) *Influence upon after-imagery.* In 1923, Frank[5] found that after-images tend to fit themselves to the form of tridimensional objects, even when the objects are drawn on a flat surface. In 1920,[6] Fuchs noticed that persons suffering from functional hemianopsia (one half of the retina blind) were able to see a completed figure when half of it fell upon the sensitive part of the retina and half upon the blind part, provided *the stimulus formed a complete configuration,* that is, *made a sensible or better figure.* Complete after-images of these

[4] Cf. Helson, H., "The Psychology of Gestalt." *Amer. J. of Psy.,* 1925, Vol. 36, 511. Cermak, P., and Koffka, K., Untersuchungen über Bewegungs und Verschmelzungsphänomene, *Psy. Forsch.,* 1922, Vol. 1, 66–129.

[5] Frank, H., "Ueber die Beeinflussing von Nachbildern durch die Gestalteigenschaften der Projektionsfläche." *Psy. Forsch.* 1923, Vol. 4, 33–41.

[6] Fuchs, W., "Untersuchungen über das Sehen der Hemianopiker und Hermiamblyopiker." Pt. 1, *Zeit. f. Psy.,* Vol. 84, 1920, 67; Pt. 2, Vol. 86, 1.

figures were occasionally seen; sometimes after-images of an incomplete figure were more complete than the figure itself. In 1923 Rothschild [7] discovered that after-imagery of relatively nonsense white figures upon black backgrounds tend to become better figures or more sensible, than the original stimuli. Configurations actually form in the after-imagery, resulting in the elimination of 'errors' and 'irregularities' in the originals; outlines of figures, incomplete in the originals, are frequently complete in the after-imagery.

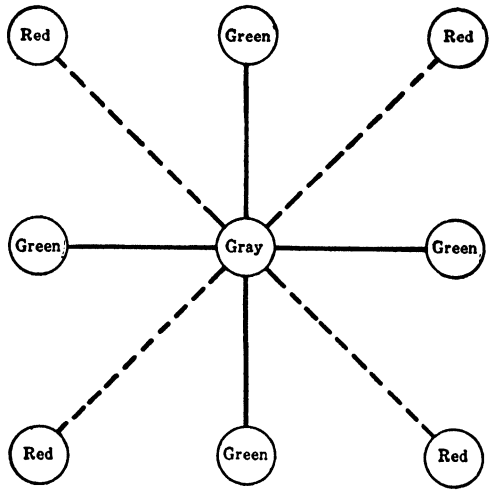


FIG. 51. DIAGRAM OF AN APPARATUS THAT DEMONSTRATES THE INFLUENCE OF CONFIGURATION UPON COLOR (Fuchs).

(2) *Influence of Configuration upon Color.* The possibilities of showing the influence of form upon color are numerous. As a single illustration consider Figure 51. If the gray circle in the center is seen as the center of an X whose ends are red, it will likewise look green when the X is regarded as a whole, but *care must be taken not to isolate the center from any other portion of the figure.* If the gray circle is seen as the center of a plus-sign whose ends are green it will take on green instead of red. The experiment will not be success-

[7] Rothschild, H., "Ueber den Einfluss der Gestalt auf das negative Nachbild ruhendere visueller Figuren." *Arch. f. Ophthalmol.*, 1923, Vol. 112, 1–24.

ful unless the figures are seen as wholes without any attempt to analyze them into their parts.[8]

Theories of Vision. The problems involved in attempting to account for all the phenomena of vision are so numerous and the available facts so few in comparison that there are no well established theories. The first of these problems is concerned with the retinal mechanisms that respond to light; these mechanisms must be conceived in such a way as to account for hue, brightness, intensity, adaptation, contrast, mixture, color blindness, and so on.

The Helmholtz Theory of Color Vision. Taking his cues from Thomas Young (1807), Helmholtz assumed the presence, in the retina, of three photochemical substances responding to red, green and blue-violet. White light was supposed to decompose all of these substances at the same time, thus yielding sensations of whiteness (analogous to the fact that the three physical lights, red, green and blue-violet unite and form white light). Various wave-lengths were supposed to stimulate different amounts of these three substances; the relative amounts to which each substance was stimulated determined the color that was perceived. A relatively long wave-length, like orange, stimulated the red substance most, to some extent the green substance and to a very slight extent the blue-violet substance thus producing the sensation orange. A relatively short wave-length like blue, decomposed the blue-violet substance most, to some extent the green substance and to a very slight extent the red. Helmholtz' chief difficulties arose in explaining (1) black, which physically is the absence of light but psychologically is a positive sensation, (2) contrast phenomena and (3) color-blindness.

Hering's Theory of Color Vision. Hering proposed a theory based upon the supposedly elemental nature of red, yellow, green, blue, black and white, when regarded from the psychological and physiological standpoints. He assumed the existence of three pairs of photochemical substances in the retina: a red-green, a yellow-blue and a black-white substance.

[8] Fuchs, W., "Experimentelle Untersuchungen über die Aenderung von Farben unter dem Einfluss von Gestalten." *Zeit. f. Psy.*, 1923, Vol. 92, 249–325.

He supposed that red, yellow and white decomposed these substances and that green, blue and black built them up. Under all conditions of stimulation each substance tended to maintain its equilibrium. If external light disintegrated the red-green substance, giving a sensation of red, there was automatically induced a corresponding building up process which accounted for the after-image of green and for green contrast phenomena. Color mixture was explained by simultaneous tearing down and building up processes. In case of complementaries these two sets of processes cancelled one another. But Hering's theory also encountered certain difficulties: (1) That sensory processes of any kind were due to building up rather than tearing down processes was hard to conceive. (2) One actually sees gray when complementaries are mixed. Hering was forced to regard this gray as a central product, a product of the brain rather than of the retina.

The Ladd-Franklin Theory. Ladd-Franklin combined certain features of both the Hering and Helmholtz theories. In her theory the primitive eye was color-blind; its retinas contained 'gray' molecules the decomposition of which in different degrees gave grays of different brightness. In the course of evolution a part of the gray molecule differentiated into a yellow-blue molecule which longer wave-lengths (yellow) affected in one way and shorter wave-lengths (blue) in another way, thus giving rise to yellow and blue sensations. These differentiated molecules were distributed over the yellow-blue zone. Later in the course of evolution the yellow halves of the yellow-blue molecules, located in the center of the retina, redifferentiated into green and red. Like the Helmholtz theory, hers had difficulty with black, with the phenomena of contrast and with retinal zones.

Recent Work on Color Theory: Venable. Recent and more elaborate investigations bearing on color theory carry us far into physics and mathematics. Venable,[9] for instance, has been working on the hypothesis that atoms in the rods and cones absorb light according to the *quantum* theory; when absorption takes place an electron is expelled from an inner to an outer orbit. Action on the visual purple is thought to be

[9] *Amer. J. Physiol. Optics,* Vol. 6, 1925, 403–415.

expressible in these terms. (The visual purple is a 'pigment' identified with the rods, which bleaches with light adaptation and returns in dark adaptation.) In a general way color sensations are ascribed, (1) to the expulsion of electrons from their normal positions in the electron system and (2) to the absorption of *quanta* of energy by the nerve material of the retina. After-images are ascribed to the return of electrons to their normal position.

Schanz' Theory. In a similar way Schanz[10] (died 1924) believed that an electronic emission was responsible for the facts of vision. In his theory electrons are emitted from the pigment just external to the rods and cones with a velocity dependent upon the wave-length of the impressed light. These electrons, striking the membranes at the ends of the receptors, set up nerve currents whose wave fronts are dependent on the velocity of the electron. Within limits, two sets of electrons expelled from the pigment atoms at different rates of velocity because of the coincidence of two or more colors, tend to equalize each other, reach the adjacent cone at a common velocity, and give the effect of an intermediate hue. If the colors are too different to allow for this equalizing of velocity we have an undifferentiated sensation, white. The theory finds greater support in known physical facts than the earlier ones, and certain other evidence substantiates it. For instance, Schanz calculated that there should be a complementary to yellowish green in the ultra violet, which, if proved, would be fatal to such a theory as that of Hering. He reports an investigation in which this was done. That is, he added a normally invisible light to a visible colored one and obtained a white resultant.

Forbes' Theory. Forbes,[11] an American entomologist, has proposed an interesting explanation of color vision based upon interference phenomena in light. These interference effects are seen in the coloring of insects' wings and scales, in thin films of oil, and in soap bubbles. His theory supposes

[10] Schanz, L., "A New Theory of Vision." *Amer. J. Physiol. Optics,* Vol. 4, 1923, 284; also *Zeit. f. Sinnesphysiol.,* Vol. 54, 1922, 93–101.

[11] Forbes, W. T., "An Interference Theory of Color Vision." *Amer. J. Psy.,* 1928, Vol. 40, 1–25.

that *maxima* of 'standing waves' are set up in the cones by the reflection of part of the light back toward the front of the eye. The position of these standing waves is dependent upon the wave-length, that is, the color of the light. He then supposes that there is a membrane across the cone at the point where one of these standing waves will come. He supposes three sets of receptors as in the Hering theory. In the red-green cone this membrane will come at the point for the yellow maxima. Red waves will be beyond the membrane and will cause more photochemical action to go on there, thus balancing the cell and increasing its rate of impulses to the brain. Green waves will come below the membrane and cause an inhibition of the normal state. Similarly in the yellow-blue cone, the membrane is at the maxima for the green, blue inhibiting and yellow increasing the normal action of the cone. A third set of cones gives a white-black series. It is in the combinations of these effects, much as in the Hering theory, that he explains the more complex phenomena of vision.

Hecht's Investigations. Hecht[12] has performed elaborate experiments upon the ascidian *Ciona* and the clam *Mya* whose responses to light may be measured by the retraction of their siphons. He has measured the velocity of the photochemical decomposition that results from exposures to light and finds that it increases during dark adaptation. Further, he obtained evidence pointing to two important steps in the transition process from the light stimulus to the nerve impulse. First, there is a certain concentration of photochemical substances which varies in a measurable fashion as adaptation varies, and second, there is an induction of a reciprocal change which apparently obeys the laws of bi-molecular action. As a result of his investigations it becomes evident that adaptation and its associated properties are phenomena controlled not by the sense organ but by the outside light. Strictly speaking the animal does not adapt itself to the light; the light adapts the animal to *it;* the light produces and then maintains the reacting elements in the light-response.

[12] Hecht, S., "The Visual Discrimination of Intensity and the Weber-Fechner Law." *J. of Gen. Physiol.*, 1924, Vol. 7, 235–267.

Hearing

The Auditory Stimulus. The stimuli for sound are wave motions of the longitudinal type occurring in a 'material medium.' The range of frequencies to which the ear will respond runs from a lower limit of 20 to 30 double vibrations per second to an upper limit of 30,000 to 50,000? per second. (The expression, double vibration, refers to the fact that a single sound wave involves two opposite and approximately equal excursions of the vibrating medium.) Periodic waves

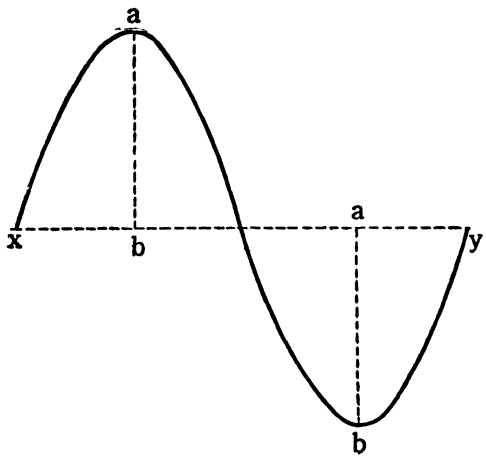


Fig. 52. Diagram Representing a Sound Wave.

give rise to tone sensations; imperfect or aperiodic waves give rise to noise. In the production of practically any tone there is a certain amount of noise.

Amplitude of the Sound Wave as a Condition of Hearing. The sound wave is conveniently pictured as in Figure 52. Its amplitude, represented by the line a–b, may vary independently of wave frequency or wave form and plays a large part in conditioning the *intensity* or loudness of auditory sensations. Weak sounds are produced by waves of low amplitude and loud sounds by waves of high amplitude.

Wave-length as a Condition of Hearing. The wave-length (x to y) or the frequency of the wave, conditions the

pitch of auditory sensations. The lowest tone produced by a grand piano, A_2, has a frequency of about 26 d. vibrations per second and the highest tone, C^5, has a frequency of 4,095. An instrument called the *lamella* demonstrates the lowest audible frequencies, which may run as low as 15 per second; the Galton whistle demonstrates the highest audible frequencies, as do also the high pitched 'songs' of insects.

Wave-form or Complexity as a Condition of Hearing. The simplest form of a sound wave is pendular as well as periodic, that is, both excursions are alike, smooth and regular, and are reduced to simplest terms in the form of a sine wave (see Figure 52). The ordinary stimulus that produces a tone sensation is a complex wave, non-pendular in character, which can be reduced to a series of pendular waves according to Fourier's theorem. The longest of these pendular waves has the same frequency as the non-pendular wave, and the other pendular waves have a frequency of 2, 3, 4 . . . n times that frequency. Each one of these 'component' waves produces its own tone, called a partial; the lowest partial is called the fundamental and the other partials are called overtones. These component waves are caused by the sound-producing body vibrating as a whole and at the same time in fractions of its length.

Let a single wire string be stretched across a sounding board (sonochord) and adjusted to produce a tone of 128 d. vibrations, one octave below middle C. The string, vibrating as a whole, produces the fundamental tone of 128 vibrations per second, but it also vibrates in halves. This can be demonstrated by the simple expedient of dampening the string exactly in the middle with a fine water-color paint brush or a light object of similar nature. Pluck the string first to produce the tone as a whole, then dampen it in the middle and the fundamental drops out. A tone will be heard, known as the first overtone, whose frequency is twice that of the fundamental, and in pitch it will be an octave above the fundamental. The string can also be dampened one third of its way across and the second overtone brought out whose frequency is three times the fundamental, and so on. The following table shows the lower nine overtones of small octave C.:

TABLE XII

FIRST NINE OVERTONES WITH *C* AS THE FUNDAMENTAL

Partial	Note	Ratio to Fundamental	Frequency	Musical Interval
Fundamental	C_0		128 d.v.	
1st overtone	C	1–2	256	octave
2nd overtone	G^1	1–3	384	octave and a fifth
3rd overtone	C^1	1–4	512	two octaves
4th overtone	E^2	1–5	640	two octaves and a third
5th overtone	G^2	1–6	768	two octaves and a fifth
6th overtone	B flat^2	1–7	896	two octaves and a seventh
7th overtone	C^3	1–8	1024	three octaves
8th overtone	D^3	1–9	1152	three octaves and a second
9th overtone	E^3	1–10	1280	three octaves and a third

Overtones and Timbre. Nearly every tone-producing instrument has a vibrating body such as a reed, a string or a thin column of air, supplemented by a resonating chamber. Because of their shape, different musical instruments emphasize certain overtones and dampen others; the result is a variety of tones of different quality. This quality is called *timbre* or *clang*. To illustrate, a piano tone contains a long series of overtones which account for its brilliance; the flute has a much shorter series of overtones; the trumpet and bassoon emphasize the higher overtones; the organ pipe and French horn emphasize the lower ones; the clarinet emphasizes the odd numbered partials, and so on.

The Laws of Tonal Sequences. There are certain laws which govern the effects produced by tonal sequences. Tones that bear given mathematical relationships to each other produce *melodic* effects when heard in sequence. These progressions of tones are orderly and satisfying; each tone seems to be allied with its neighbor. But other sequences, not bearing given mathematical relationships, do not show these characteristics, or at least reveal them to a less extent.

The first law of tonality is the *law of the tonic:* When a sequence of tones is given and one of the tones possesses a vibration ratio of *two* with respect to any other given tone (say the ratio of 2:3, 2:5) the tone with the ratio number *two* makes the best ending.

The second is *the law of cadence:* The lowest of a series of tones, other things being equal, makes the most satisfying ending for a sequence (especially in the absence of a tonic).

The third is the *law of return:* In ending a melody it is more satisfying to return to the starting point or to a prominent tone that appeared near the beginning of the melody. (This tone is frequently the tonic.)

The fourth is the *law of equal intervals:* Unless the pitch differences employed in tonal sequences are equal intervals and multiples of these intervals, the sequence is unsatisfactory from the standpoint of melody (Ogden).

Interrelationship of Tone Qualities. It was found that in vision all the perceptible qualities might be grouped into two classes, brightness and color. There is a somewhat similar grouping of auditory sensations into tones and noises, but the relationship between the latter is different in that color is obtained from an analysis of white light, while tones are not obtained by analyzing noises, except within very narrow limits. On the other hand, there may be a resemblance of function in the twofold classifications; brightness vision may have appeared before color vision in the evolution of the eye, and the primitive auditory sense may have brought the organism into contact first with a world of noises and later with a world of tone.

Corresponding to the color pyramid for vision a figure has been constructed to portray the interrelationships of tone properties of which there are: *Pitch, timbre, intensity and volume.* Drobisch in 1885 first conceived the idea of a spiral as a convenient scheme, to which Ruckmick has recently made certain additions. Ruckmick's figure[13] is the 'tonal bell' (Figure 53). The circumference of the spiral indicates the volume of the tone; the steeper the ascent the fewer discriminable differences in volume as pitch is varied. Thus the volume of tones of low

[13] Ruckmick, C., *The Mental Life.* Longmans, 1928, 40.

pitch is relatively great but the diminution is rapid for the first two octaves. Then for three or four octaves there is very little change in volume, until near the upper end of the tonal range where the change is rapid again, the tones becoming much smaller with each octave.

Differences in Simultaneous Wave Frequencies as a Condition of Hearing: Beats. When two tones of the same pitch (same wave frequencies) are produced simultaneously their intensities summate. When two tones of slightly different pitch are sounded together there appear marked periodic fluctuations or *beats* in the intensity of the total auditory impression. Figure 54 shows how they are produced. A sound wave is a periodic, successive rarefaction and condensation of a 'material medium'; consequently when two waves are set up, one slightly faster than the other, there is a point at which the condensation processes occur together. But by the time the opposite phase is reached in the one, the other wave is lagging a little behind. Eventually a condensation process in one series of vibrations is occurring at the time a rarification process takes place in the other, as indicated by *C* in the diagram. Then the two opposite phases counteract each other and as a result there is a diminution in the intensity of the tone. When the condensation processes are going on simultaneously as at *D* there is a summation, an increase in the

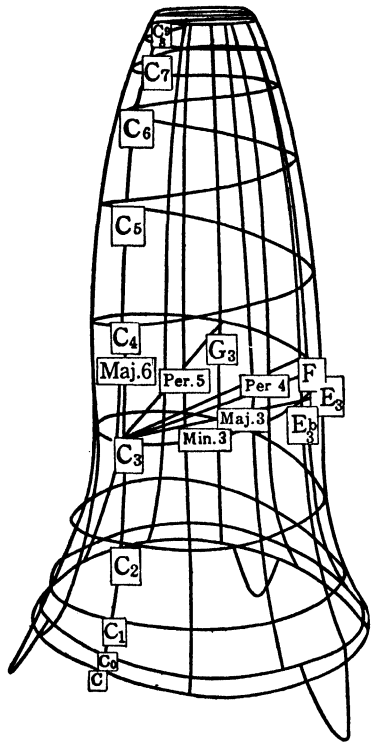


FIG. 53. TONAL BELL (Ruckmick).

From Ruckmick, *The Mental Life*, 1928. By permission of Longmans, Green, publishers.

intensity of the tone. It is easily calculated that if the difference in rate of vibration of two tones is five vibrations per second there will be five beats per second. Separate the pitches of the two tones sufficiently and the beats occur too rapidly to be counted, yet they can be perceived. Finally, with the pitches of the tones far enough apart the beats lose their identity altogether and the tones are heard distinctly, but as a discord.

Intermediate Tones. Under certain conditions beats produce their own tones, called *intermediate tones*. When the original or generating tones are only slightly off pitch no intermediate tone is distinguishable. If gradually the difference between the generating tones is increased an intermediate

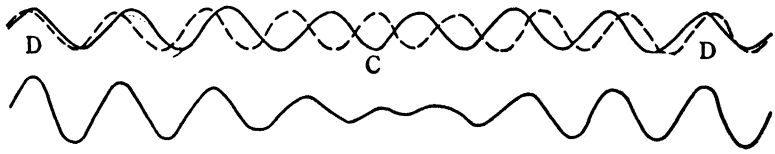


FIG. 54. DIAGRAM SHOWING HOW BEATS ARE PRODUCED.

tone of low pitch can be heard. This rises from the lower toward the higher generating tone as the beats increase in number. The intermediate tone finally vanishes as the two generating tones take on distinctness.

Difference Tones. If two relatively high tones are sounded whose pitch difference is at least thirty vibrations per second, another type of tone can be heard called a *difference tone* whose vibration rate is the same as the pitch difference of the generating tones. It is claimed that a single pair of tones will give rise to as many as five audible difference tones. Let u represent the upper of the original tones and l the lower, and suppose u to be a tone of 1536 and l a tone of 1212 vibrations. The first difference tone D_1 is u-l or 324; the others are produced by the frequencies indicated:

Second difference tone $D_2 = l - D_1$ or $2l - u = 888$
Third difference tone $D_3 = D_2 - D_1$ or $3l - 2u = 564$
Fourth difference tone $D_4 = D_3 - D_1$ or $4l - 3u = 240$
Fifth difference tone $D_5 = D_1 - D_4$ or $4u - 5l = 84$

There is still another effect produced by combining two tones, namely the *summation tone.* The summation tone has a frequency equal to the sum of the generating frequencies. Difference and summation tones, taken together, are called *combination tones.*

The Problem of Consonance and Dissonance. It was found that in vision certain colors would not mix; they seemed to be intrinsically antagonistic and when whirled in a color mixer they cancelled each other out. On the other hand, certain colors were found to fuse as a result of which a new color was formed. The phenomenon of *fusion* is likewise found in the blending together of two or more tones. There are also tones that do not blend, or at least give the impression of not blending. The former is called *consonance* and the latter is called *dissonance.*

It is interesting to note that tones which produce consonant intervals are precisely those which are heard most often together, namely, a fundamental and its first few overtones, the octave, the octave and fifth, octave and third, and so on. When a single tone is sounded there is actually heard a simple chord. When chords like an octave, a fifth and a third are heard they seem to be as simple and familiar an experience as a single tone. This may be the reason why the chords are characterized as consonant, pleasant and smooth. But let two or more tones be sounded together whose product is less familiar, less like a single tone, and the effect is a discord or a dissonance which is rough and unpleasant. Helmholtz advanced the theory that the presence of beating overtones in the case of dissonance and the lack of beats in the case of consonance explained their difference. But whether or not a chord is to be regarded as a consonant or a dissonant is relatively independent of beats and independent of any conscious analysis the listener makes of the tonal complex. What definitely constitutes the differences and what other conditions are involved remain to be determined.

Absolute Pitch. There are certain individuals who can judge the exact pitch of a tone the instant it is played; strike a chord and they can tell. instantly, the key in which the chord is played. Although considerable effort has been made to solve

the problem of how individuals acquire their 'sense' of absolute pitch, no definite answer can be given. It is true that where music is taught children early in life, with an emphasis upon memorization of selections, absolute pitch frequently develops. It is very common, for example, among pupils in schools for the blind. It seems to be a matter of responding to a stimulus in relation to a total configurational pattern. A person possessing a sense of absolute pitch hears the tone in its detailed

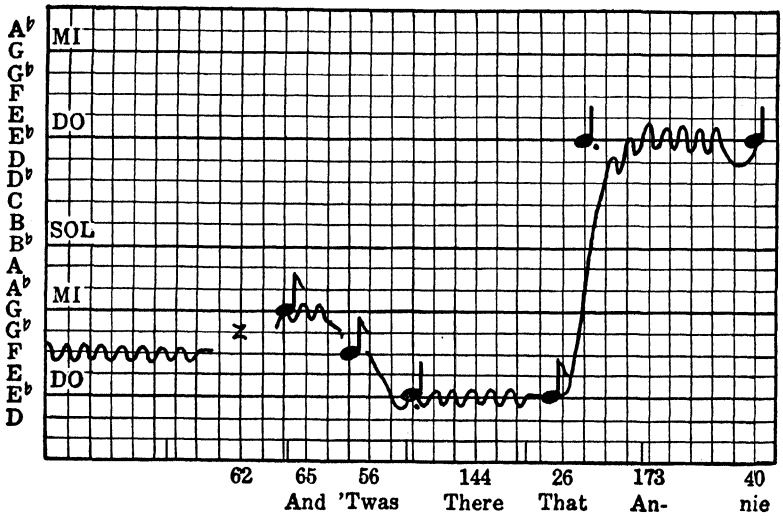


FIG. 55. PHONOPHOTOGRAPH OF THE HUMAN VOICE (Metfessel).

relationships to the entire tonal range, but more particularly in its relationships to a certain octave.

Phonophotography of Sounds. By using mechanical devices too complicated to describe here (phoneloscope, Seashore tonoscope, etc.) Metfessel[14] has recorded the pitch variations of the human voice. Figure 55 shows how McCormack sang a phrase from 'Annie Laurie,' taken off a phonograph record. The waves represent variations in the pitch of a sustained note. Horizontal columns indicate halftone intervals; notice that the variations in pitch are almost

[14] Metfessel, M., "Technique for Objective Studies of the Vocal Art." *Psy. Mon.*, 1926, Vol. 36, 1–40; *Psy. Mon.*, 1928, Vol. 39, 126–134.

a half tone in extent! This procedure offers promise of ascertaining what constitutes emotional expression in music and speech.

The Ear as a Condition of Hearing. Environmental sounds find their way to the sensitive portions of the ear through an external canal, the *meatus,* to the ear drum or *tympanic membrane* (Figures 56 and 57). Then they are transmitted over a chain of three little bones, the *malleus, incus* and *stapes,* that form a bridge across a chamber known

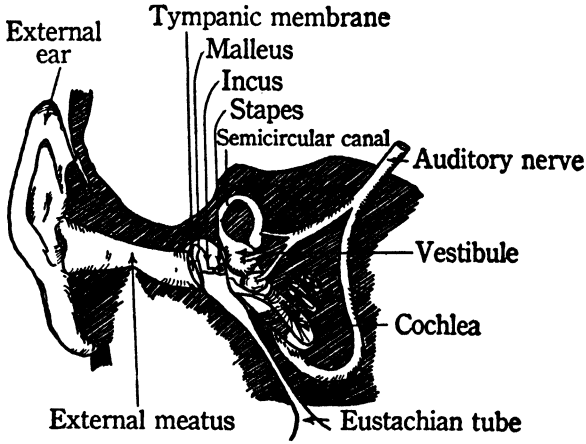


FIG. 56. THE ORGAN OF HEARING.

as the *middle ear.* The malleus is attached to the tympanic membrane on one side of the chamber and the stapes is attached to a membrane called the *oval window* on the other side. From the oval window the vibrations pass to a vestibule and hence into a tunnel, the *scala tympani,* filled with *perilymph,* a type of watery, lymphatic fluid. The tunnel is roofed over with bone; its floor is made partly of bone, the *lamina spiralis,* and partly of tissue, the *basilar membrane.* Cutting off one section of this tunnel longitudinally, just over the basilar membrane, is another partition called *Reissner's (vestibular) membrane.* The space between Reissner's membrane and the basilar membrane is called the *scala media* or *ductus cochlearis.* Below the scala tympani is another tunnel called the

scala vestibuli which articulates with the middle ear by means of a membrane called the *round window.* All tunnels together curve about a central axis two and a quarter times, becoming smaller as they approach the upper end. This double tunnel with its axis and bony wall is called the *cochlea.*

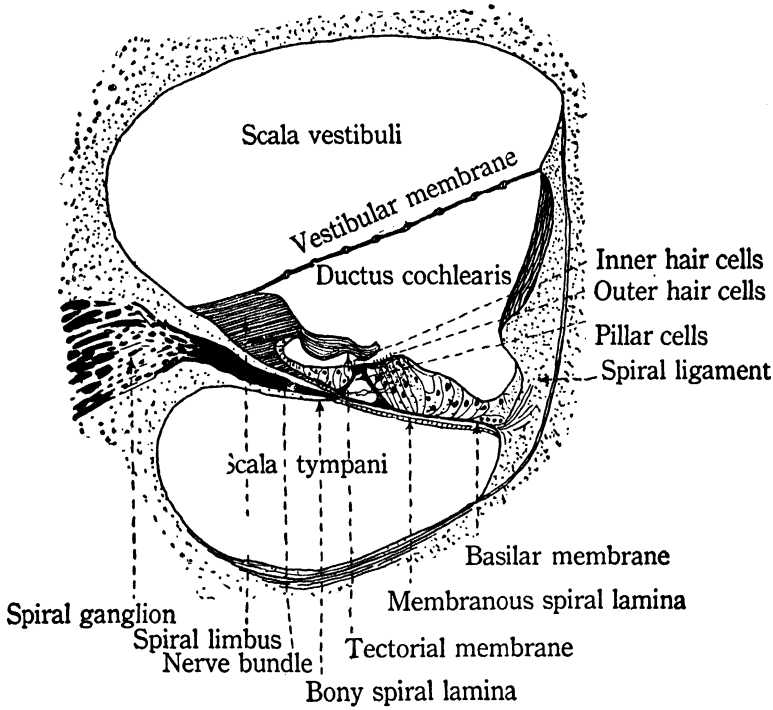


FIG. 57. CROSS-SECTION OF THE 'TUNNELS' OF THE COCHLEA.

The main tunnels are the *Scala vestibuli, Scala tympani,* and *Ductus cochlearis.* Note the position of the *Basilar membrane* and the bony part of the partition (*Bony spiral lamina*). Nerve fibers converge from the *hair cells* and form the *Nerve bundle.* These fibers end in the *Spiral ganglion.* The nerve route to the brain is continued by other cells which extend from the *Spiral ganglia* to the central axis of the *Cochlea.* Fibers converging into this axis constitute the auditory nerve which eventually enters the base of the brain. *The Scalae vestibuli* and *tympani* are filled with perilymph; the *Ductus cochlearis* is filled with endolymph.

If one imagines the complete tunnel of the cochlea unwound and the scala vestibuli opened so that the roof of the scala tympani is visible, the bony part of the partition, which always lies close to the central axis, is seen to become narrower toward the upper end of the cochlea, and the basilar membrane is seen

to become wider. Resting upon the edge of the basilar membrane next to the bony part of the partition, a ridge of cells may be seen running the entire length of the cochlea. This ridge or mound is the *organ of Corti* which contains columns of sensitive *hair cells,* the receptors for hearing. Above the organ of Corti hangs the *tectorial membrane* into which the hair processes from the nerve cells penetrate.

Owing to their peculiar position and manner of vibrating, the three little bones of the middle ear sharpen the vibrations passed to them through the tympanic membrane, possibly reducing the amplitude of the displacements. Vibrations reaching the oval window are then picked up by the liquid of the cochlea. Much discussion has centered in the question just how the vibrations are picked up by the sensitive hair cells. It was seen that all theories of vision recognized the importance of the retina as an analyzer; there were supposed to be differentiated substances in the retina which responded differently to different wave-lengths of light. Does the ear perform a similar function? Are there differentiated structures in the cochlea which select tones of different pitches from a complex sound?

Helmholtz' Theory of Hearing. Helmholtz advanced the theory that because the basilar membrane contained transverse fibers it might be likened to a set of piano wires, each having its own vibration rate and each acting as a resonator. If the basilar membrane possessed this function of responding sympathetically to displacements in the surrounding liquid, hearing might be explained very neatly. Slow frequencies would be picked up at the wider end of the basilar membrane and the faster frequencies at the narrower end. A single tone, with its overtones, would set in motion different sections or strands of fibers along different portions of the membrane. The Helmholtz theory met with serious objections, however: (1) While there are enough fibers to accommodate all the discriminable pitches, the fibers are too similar to act as resonators; (2) they are not *stretched* and could not function as resonators. Still the resonance theory has ardent supporters.

Opposed to the resonance theory are several of another type the main point of which is the idea that vibrations pass to

the liquid of the cochlea and are picked up by the hair cells of the organ of Corti as complete, unanalyzed vibrations. In this case the nerve fibers from the cochlea to the brain would carry unanalyzed waves in a fashion similar to telephone wires. The brain would then make the necessary analyses.

Meyer's Theory of Hearing. Only a few theories of this type can be mentioned. Max Meyer [15] first announced a hydraulic theory of hearing in 1898. In his view intensity of tone is ascribable to the extent of lateral displacement of the basilar membrane as the thrust of the stapes is strong or feeble. Pitch is ascribable to the frequency of the displacements. When a tone is sounded a bulge is formed in the basilar membrane at the oval window; this bulge (displacement) lengthens to a position whose distance from the oval window is conditioned by the intensity of the tone. In 1909 Yoshii [16] subjected numerous guinea pigs to tones of different pitch for three months without rest. Degeneration of cells and scar tissue were found farther away from the oval window in case of low tones and nearer the window in case of high tones, a fact which Meyer interprets in support of his theory. According to the hydraulic theory any injury should come at the end of the tone's 'sphere of influence' upon the basilar membrane, and, according to Meyer, it can be shown that this sphere of influence is shorter for high than for low tones.

Ewald's Theory. In 1899, Ewald [17] advanced a different theory based upon observed movements of elastic membranes. When sounds are produced in the vicinity of a structure like the basilar membrane there develops a pattern of stationary displacement in the membrane that persists as long as the tone lasts. Ewald calls this pattern an *acoustic image* or *sound picture.* The number of transverse lines and the distance between them are determined by the pitch of the tone. This pattern of displacement would in turn produce corresponding displacements of the hair cells resting on the basilar

[15] Meyer, M. F., "The Hydraulic Principles Governing the Function of the Cochlea." *J. of Gen. Psy.*, 1928. Vol. 1, 239–265.

[16] Yoshii, *Zeit. f. Ohrenhk.*, 1909, Vol. 58, 201–251.

[17] Ewald, J., "Zur Physiologie d. Labyrinths." *Arch. f. d. ges. Physiol.*, 1899, Vol. 76, 147 ff.

membrane. We must then imagine that the pattern of nerve disturbance is translated into sensations of tones.

Other Theories of Audition. Recently several theories of hearing have been proposed, some of which are primarily based upon the facts of sound localization. Boring [18] has proposed a central analysis theory which attempts to explain intensity of tone by the specific number of nerve fibers stimulated at any one time, and the quality of tones by the frequency of the displacements. Volume is thought to correlate with the extent of excitatory dispersion; and localization of sounds, based on intensity differences, is referred to cortical dispersion and to the functioning of adjacent brain areas. The fact that nerve cells respond maximally or not at all (the all-or-none law, page 494), makes a resonance theory unsatisfactory, according to Boring. But other investigators are simultaneously advocating a modified resonance theory (Banister, et al.) and claim to find support in experimental data. Which principle is the more satisfactory, the resonance view or the theory of central analysis, remains to be determined. In the meantime the resonance type seems to be favored as the one which accounts for the greater number of facts.

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[18] Boring, E. G., "Auditory Theory with Special Reference to Intensity, Volume, and Localization." *Amer. J. of Psy.*, 1926, Vol. 37, 157–188.

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CHAPTER XV

OBSERVATIONAL BEHAVIOR: FINER ASPECTS THE LOWER SENSES

EQUILIBRATORY SENSITIVITY

The Organ of Equilibrium. Situated in the bones of the head, adjacent to the middle and inner ears, is a labyrinthine structure consisting of a *vestibule* and three *semicircular canals* (Figure 58). The vestibule is divided into two

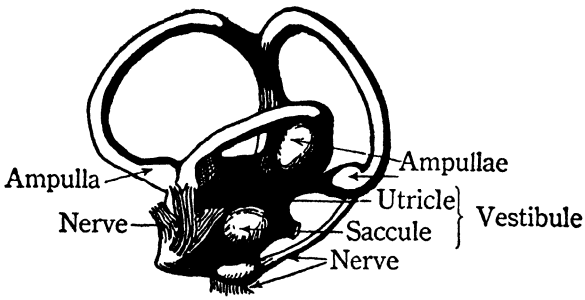


FIG. 58. THE ORGAN OF EQUILIBRIUM.

parts, the *saccule* and *utricle,* in the recesses of which are to be found areas of hair cells. These cells support tiny crystals of bone, called *otoliths,* and with them they lie in a viscous substance that lines the floor of the vestibule. The semicircular canals connect with the vestibule and lead out from it in such a way that a loop is made in each of the three geometrical planes. At one end of each of these canals is an enlargement called the *ampulla* from the inner wall of which a tuft of hair-cells known as the *crista* extends into the canal. There are, then, five masses of receptors in the labyrinthine

organ, two in the vestibule and three in the ampullae of the semicircular canals.

The Conditions of Equilibratory Response. (1) *Stimulation of the Vestibular Organs.* The vestibular sense, as it is sometimes called, is apparently brought into play whenever the position of the head is sufficiently changed to disturb the organism's orientation to gravity. When a person dives, for example, he can always tell when he is swimming head down. Deaf-mutes, however, whose difficulty is due to a degeneration of the cochlear hair-cells, frequently suffer a degeneration of the vestibular sense as well, owing to a connection between the cochlear and the vestibule through which inflammation spreads. As a consequence, these individuals have been known to lose their orientation while under water because they are evidently defective in their sense of equilibrium. Kreidl, by an ingenious method, was able to produce forced movements of the crayfish in any desired direction by bringing a magnet in close proximity to its head, after iron filings had been substituted for the otoliths. Facts of this general nature lead psychologists to believe that the vestibular sense functions in the organism's orientation to gravity. Kreidl's experiments suggest the method by which the end organs in the utricle and saccule are stimulated. Shifting the position of the iron filings in the saccule of the crayfish released pressure from certain nerve endings and increased it on others. Likewise in human beings pressure of the otoliths upon the underlying nerve endings apparently varies with different positions of the head, and this difference in pressure may be the mode of their stimulation.

Evidence of the functioning of the vestibular organs is also seen in adjustments to a centrifugal force. The rider leans inward when turning a sharp corner on a bicycle; a similar orientation of the body is observed on the merry-go-round. Here again negative evidence is at hand; there are deaf-mutes who will not lean toward the inside and hence can not be permitted to ride on a merry-go-round because they fall off. But let a normal rider close his eyes, while he supposedly holds a stick in a vertical position and he will tilt the stick parallel with his body in the belief that both are vertical. Evidently

the recesses of the vestibule are so situated that the otoliths will be affected no matter in what plane movements of the body take place. In the particular case of centrifugal force, the otoliths probably shift outward, changing the pressure upon the underlying end-organs, and hence set up balancing 'reflexes.'

Everyone has had the experience, while riding in a Pullman berth, of noticing the motion of the train as it was losing and gaining speed, but of not noticing it as long as its speed was uniform. So too, everyone is familiar with the 'hurled through space' experience of riding in an elevator. Change in *rate* of motion as well as in direction is, therefore, a condition of vestibular response.

(2) *Stimulation of the Ampullar Organs.* Our knowledge of the semicircular canals traces back to experimental work in 1825, by Flourens, who destroyed one or more of the canals in pigeons and observed how the operation affected their behavior. He found that a disturbance of movement appeared in the plane of the affected canal. With a lesion of the *right horizontal* canal the bird continuously rotated in circles to the *right,* and moved its head sidewise in the same direction. When *both sets* of canals were destroyed the bird showed muscular weakness, complete loss of balance and a loss of practically all co-ordinated movements.

Simple experiments on human subjects, as spinning them around on their heels, or turning them rapidly in a revolving chair, and also experiences on shipboard, point to the conclusion that dizziness and swimming sensations are caused by stimulation of end-organs in the semicircular canals. Pathology also furnished evidence, for nearly 50 per cent of deaf-mutes will not become dizzy when they are rotated.

How then are the nerve endings in the ampullae stimulated? Between 1873 and 1878, Mach, Breur and Brown independently advanced the theory that changes in position of the head cause currents of endolymph to flow back and forth through the canals. These currents either bend the cristae or shift the hydraulic pressure against them, in this way setting up nerve impulses to the brain. No matter in what plane a movement of the head takes place, the liquid in one canal or

another will lag when the motion begins and will continue to flow by inertia when motion stops. A simple test of the theory can be made by irrigating the meatus with hot water; currents thus set up in the canals give the observer the feeling of being rotated.

Compensatory Movements. When a person is dizzy he is inclined to sway and reel. Let his head be tilted suddenly and at once he makes head movements in the opposite direction. Let someone attempt to push him over; immediately he braces himself by straining in the reverse direction. All of these are cases of *compensatory movements.* Offsetting centrifugal force is another example; if a person's body is rotated or pulled to the right he tends to turn or lean to the left. Moreover, with compensatory movements of his body, there occur analogous movements of his eyes.

Compensatory movements are constantly taking place in maintaining the position and equilibrium of the body while at rest, and in controlling its poise and direction during locomotion. Of course the balancing movements are not noticed unless the disturbance of equilibrium is sufficient to make imminent the danger of falling or of doing oneself a bodily injury.

Certain compensatory movements are so regular that they have been used as measures of equilibratory sensitivity; among them are eye-movements. These can easily be demonstrated by revolving a person rapidly in a chair several times and then stopping him suddenly. For a few seconds periodic movements of the eyes to the right and left will take place, called *nystagmus* movements. The amplitude of these eye-excursions is relatively great at first, then diminishes gradually until it reaches zero. If nystagmus movements appear in a subject after a rotation of the head in each of the three different planes, it is considered evidence that all semicircular canals are functioning properly. This is the so-called Bárány test that is used on prospective air pilots. There is some question, however, concerning the reliability of such a test in predicting the aviator's equilibratory responses in an airplane.

Forced Movements. The effect of extirpating all the semicircular canals is to destroy all forms of compensatory movements. When destruction is only partial, certain of these

movements are retained and others are lost. Suppose, for example, that every movement to the right calls up a compensatory movement to the left, while movements to the left call up no compensatory reactions. The organism will then be compelled to move constantly to the left, that is, to execute *forced movements.* This is what happens when the left horizontal canal is destroyed. Corresponding forced movements occur when lesions are produced in other canals.

In certain varieties of animals there is apparently an inherited or congenital defect in one or another of the semicircular canals, as a consequence of which characteristic forced movements take place during locomotion. The Japanese or kangaroo mouse hops in circles in going from one place to another, and the peculiar somersaulting of tumbler pigeons is said to be due to a similar defect of the labyrinthine organ.

Taste: The Gustatory Sense

The Stimulus for Taste. The stimulus for taste sensitivity must be a substance to some extent soluble in the saliva of the mouth. There are four taste qualities, *salt, sweet, sour* and *bitter.* While attempts have been made to correlate these qualities with the chemical nature of the stimuli results make possible only the roughest generalizations. According to Parker,[1] the sour quality is due to hydrogen ions, salt to negatively charged ions of chlorine, bromine, iodine and certain other substances, and bitter to positively charged ions and to compounds containing the nitro group, NO_2, of which morphine, quinine and other alkaloids are examples. The sweet taste is conditioned by substances that can be dissociated into positively *or* negatively charged ions, for example the chemical sugars and alcohols. In other words, acid substances taste sour, sugars taste sweet, chemical salts taste salty and certain classes of organic compounds taste bitter. Bitter and sweet substances, although quite different as to taste, need suffer

[1] Parker, G. H., *Smell, Taste and Allied Senses in Vertebrates.* Philadelphia: Lippincott, 1922, 192.

only a slight chemical change to undergo a reversal in their taste qualities. However, these rules are subject to many exceptions.

The Taste Receptors. Taste receptors, in the adult, are located chiefly on the upper surface, sides and tip of the tongue; a few are found on the soft palate in the interior of the epiglottis and in the larynx. It is possible that children have taste organs, temporarily, in the mucous membrane of the cheeks. There is some evidence that receptors, existing during the early stages on the middle of the tongue, degenerate; at least this area is tasteless in adults and is evidently sensitive in children. The nerve endings are long slender rod-like cells, grouped together in pear-shaped structures called *taste buds*. These buds lie in the papillae and furrows of the tongue, frequently several buds within a papilla. It is fairly certain that a given bud subserves but one taste quality.

Experimental work on taste is fraught with difficulties. If the observer's mouth is dry he can not taste, and if there is an abundance of saliva in the mouth it is difficult to control the stimulus. But with caution and the use of instruments like a fine camel's hair brush or a fine pipette, limited areas of the tongue can be stimulated without affecting surrounding regions. Other difficulties must be avoided, also, such as effects of contrast and adaptation, unless of course these phenomena are the special objects of investigation. Available evidence shows that the taste buds for sweet are concentrated at the tip of the tongue, bitter at the back, and sour at the sides; salt receptors are distributed more generally over the entire surface.

Henning's Taste Tetrahedron. Henning's[2] work stands out as the most prominent of recent years in the field of taste and smell; he finds certain intermediate taste qualities which he relates to salt, sweet, sour and bitter, according to Figure 59, the *taste tetrahedron*. The intermediate tastes are not combinations of corner tastes; they are placed on the intermediate lines to indicate qualitative resemblance to the fundamental tastes of the opposite corners.

[2] Henning, H., Der Geruch. Leipzig, 1916, 533. Also *Zeit. f. Psy.*, 1915–1916, Vols. 73–76.

Duration of the Stimulus as a Condition of Taste. Continuation of the stimulus brings on adaptation in taste as it does in vision. For example, the first sip of lemonade is sourer than the last; the first mouthful of nearbeer is more bitter than the last, and so on. Also, as in vision, adaptation in taste is followed by contrast effects; an orange is much sourer after eating cake frosting; adaptation to sour enhances sweet and to some extent salt. The duration of the stimulus is correlated also with the time of appearance of different

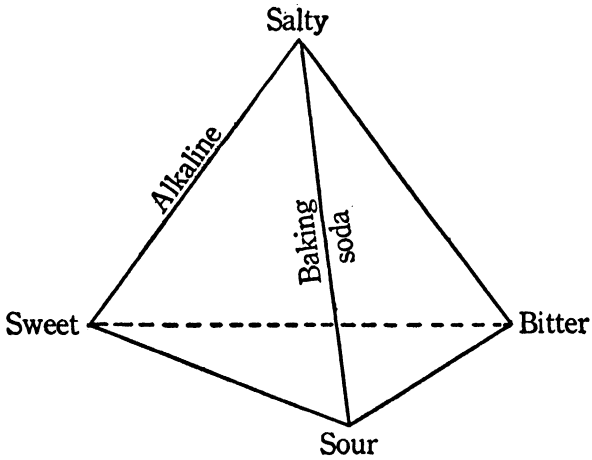


FIG. 59. THE TASTE TETRAHEDRON (Henning).

single taste qualities. Salt is the first quality to appear upon stimulation of a given papilla, sweet next, then sour and last of all bitter. These facts may be explained by the relative position of the different taste buds in the papillae; salt buds are perhaps nearest the surface and those for bitter are imbedded the deepest. If this is true the time necessary for a solution to penetrate to the bud might account for the length of delay in arousal of the response.

Complexity of Stimulation as a Condition of Taste. While there are no definite mixtures of taste qualities, there are numerous phenomena showing that certain of the taste qualities are more or less antagonistic. Sugar counteracts the bitter taste of coffee and salt relieves the oversweet taste of

melons. Careful laboratory experimentation reveals that two strong tastes, of whatever kind, do not affect each other while in case of low intensities of taste there is something of a neutralization. The least cancellation occurs in case of sweet and sour, and then in order, salt and bitter, sour and bitter, sour and salt and finally the greatest in case of sweet and bitter.

Relation between Taste and Smell. The close relationship between taste and smell is a fact of everyday experience. Foods have no 'taste' when the nostrils are closed from the effects of a cold; the disagreeable 'taste' of many a medicine can be avoided by the simple expedient of holding the breath until after one has swallowed. After taking bitter medicines relief is obtained by eating something which is practically tasteless, but has a strong odor. These facts can be understood, when upon careful analysis the 'taste' of vanilla ice cream proves to be the *odor* of vanilla, the *coldness* and *texture* of the frozen substance and the *muscular 'feel'* of compressing it against the roof of the mouth. None of these experiences is a taste; the only genuine taste quality obtained from eating ice cream is *sweetness*. Similarly, temperature perceptions and odors from seasoning dominate the taste of hot soup. While these facts do not point to an actual mixture of taste and smell qualities, they indicate that what is called the taste of a substance is a perceptual configuration growing out of a variety of different stimulations.

Smell: The Olfactory Sense

The Stimulus and Receptors for Smell. The stimulus for smell (the olfactory sense) is a gas or vapor carried by air currents to the olfactory receptors, during respiration. These currents pass through the nasal passages either from the external nostrils or by way of the *posterior nares* (rear passages into the pharynx). Odors perceived during the mastication of food are obtained in this fashion. The olfactory receptors are narrow rod-shaped cells found in the mucous lining of side pockets in the upper nasal passages. They are massed together in a small area called the olfactory region

(*regia olfactoria*). The mode of stimulation of these end-organs is probably chemical.

Character of the Chemical Stimulus as a Condition of Smell. The relationship of different types of odors to the chemical composition of the stimuli has never been definitely established; the problems involved are extremely complicated and there is as yet no agreement as to the types of odors. Linnaeus, the famous Swedish botanist (1707–1778), was the first investigator systematically to attempt a classification of odors; his grouping was accepted with certain modifications by Zwaardemaker, a contemporary Dutch physiologist and an authority on smell who classified the olfactory qualities as follows:

1. Ethereal odors, including odors of fruits, wine, ethers, beeswax.
2. Aromatic or spicy odors: camphor, cloves, ginger, pepper, anise, lavender, peppermint, geranium, sassifras, rosewood, etc.
3. Fragrant odors: including the scents of flowers, vanilla, tea, balsam and hay.
4. Ambrosial odors, such as musk and sandalwood.
5. Alliaceous odors, including onion, india rubber, chlorine, and dried fish.
6. Empyreumatic or burnt odors: burnt foods, tar, gasolene, tobacco smoke, toast, carbolic acid, creosote, etc.
7. Hircine or rank odors: cheese, rancid butter, sweat, lactic acid, etc.
8. Repulsive or virulent, foul odors: opium, French marigolds, squash bugs and bed bugs.
9. Nauseous odors: decaying flesh, faeces, etc.

Henning's Smell Prism. Recently Henning[2a] has simplified the list by reducing it to six classes the interrelationships of which he pictures by means of a smell-prism (Figure 60). The basic (simplex) or corner odors of this prism are fragrant, putrid, ethereal, spicy, burnt and resinous. Theoretically it is possible, according to Henning, to take the odor of any specific object or substance and locate it somewhere along the prism. Odors lying along any edge may be called *duplex*, since they can be described by their qualitative similarity to the

[2a] *Ibid.*

two simplex odors at the corners. There are other odors so complex that they belong somewhere on the surface of the prism, in which case they are describable in terms of the four corner odors and are called *multiplex*.

Henning made an elaborate attempt to relate these different types of odors to the chemical composition of the stimuli. The mode of connection of certain atomic groups and radicals within the benzene ring is the principle he attempted to use. His work was done on a very few observers and the chemical identification of many of his stimuli was inaccurate. Mac-

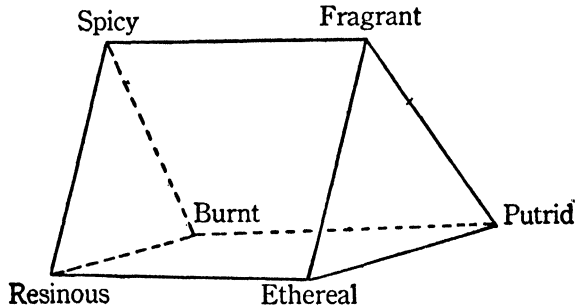


FIG. 60. SMELL PRISM (Henning).

Donald,[3] who recently repeated Henning's experiments, obtained an agreement of less than 50 per cent with the latter's classification of odors. Findley [4] succeeded in verifying Henning's results to a greater extent and concludes that while on the whole the prism does not represent a precise classification of olfactory relations, it works fairly well in depicting a tendency toward a given set of relations.

There is evidently a slight correlation between the chemical nature of the stimulus and the character of the resulting odor. It is probable that chemical elements as such are inodorous, in fact that all odorous substances contain elements from a certain limited number of chemical groups, probably the fifth,

[3] MacDonald, M. H., "An Experimental Study of Henning's System of Olfactory Qualities." *Amer. J. of Psy.*, 1922, Vol. 33, 535–553.

[4] Findley, A. E., "Further Studies of Henning's System of Olfactory Qualities." *Amer. J. Psy.*, 1924, Vol. 35, 436–445.

sixth and seventh. (The fifth group contains nitrogen, the sixth oxygen, and the seventh chlorine, iodine, etc.) When a series of compounds like the alcohols and fatty acids are arranged in order of their atomic weights, their odors change in a corresponding way until the end of the series is approached, when the substances frequently lose their odor.

Duration of the Stimulus as a Condition of Smell. Adaptation to olfactory stimuli is on the whole relatively rapid, a fact testified by everyday experience. Workers in tanneries, markets and hospitals soon adapt themselves to the odors of their particular environment. It is possible in the laboratory to measure isolated cases of adaptation; insensitivity to heliotrope is complete at the end of five minutes of continuous stimulation; adaptation to asafoetida requires only one and one-half minutes; stale cheese requires eight minutes, and so on. Although the fact is debatable, adaptation to one odor apparently raises the threshold for certain odors and lowers it for others. This is said to be true with users of perfumery, smokers, and physicians who become less sensitive to particular odors about them. When one is adapted to iodine, for instance, certain perfumes can not be smelled. However, laboratory tests cast doubt upon this.

Complexity of the Stimulus as a Condition of Smell. If by means of an olfactometer (apparatus for presentation of stimuli to the nostrils either separately or simultaneously) various odors are presented simultaneously, the observer will be able to detect neutralization and sometimes mixture. In everyday life frequent use is made of these facts of mixture and cancellation; mouth odors are counteracted with tooth paste and scented candies, and carbolic acid is used to offset foul odors. The perfume industry makes extensive use of olfactory mixtures; heliotrope is a mixture of vanilla, rose, orange flower, ambergris and almond. Almost everyone has attempted to cancel an unpleasant odor about the house, say that of a dead mouse, by pouring perfume around, only to discover that the resulting mixture is worse than the original offensive smell.

Cutaneous Sensitivity

The Conditions of Cutaneous Response. It was not until a fairly recent date that the conditions for the stimulation of the cutaneous senses were discovered and their particular effects brought to light. Prior to the eighties it was thought that the skin as such was the organ of touch, and that it was uniformly sensitive. Nevertheless, as early as 1840, Weber spoke of a separate sensibility of the skin to temperature. It was not until the eighties that the muscular (kinaesthetic) senses were definitely separated from touch, and at that time pain was still being confused with unpleasantness. In 1884, Blix [5] discovered that random pressure stimulation of the skin did not always evoke a response. Goldscheider and Donaldson [6] followed in 1885 with more results, and ten years later von Frey [7] reported on studies of cutaneous sensitivity. Their results, especially von Frey's, have stood almost unchallenged for years. These investigators abstracted from touch configurations four specialized types of cutaneous qualities: *pain, pressure, warmth* and *cold,* each of which will be considered in turn.

Pain. The technique for the experimental study of pain sensitivity consists of moistening the skin with tepid water to soften it, shaving the hairs and with a needle or sharp-pointed bristle, exploring a given area, point by point, with the help of a magnifying glass. Not every thrust of the stimulus-point will give rise to pain; on the average there will be 100 to 200 sensitive 'spots' within a square centimeter of skin surface. It has been supposed that beneath each of these spots is a receptor (free nerve ending) for pain. The spots respond not only to mechanical stimulation but also to extremes of heat and cold, to chemical changes in the tissues and to electric currents.

Pressure. Pressure sensitivity may be investigated by using a horse-hair point, two centimeters in length, attached by sealing wax to the end of a match. The advantage of the

[5] Blix, M., *Zeit. f. Biol.,* 1884, Vol. 20, 140.
[6] Donaldson, H. H., "Mind." O. S., Vol. 10, 1885, 399.
[7] von Frey, M., "Beiträge zur Sinnesphysiologie der Haut." *Ber. d. kgl. Sächs. Ges. d. Wiss. Math-phys. Kl.,* Vol. 47, 1895, 181–184.

hair lies in the fact that it provides stimulation of uniform intensity when pressed gently against the skin. If a square centimeter of surface is selected and each minute section of it is explored, there will be found on the average about 25 pressure spots, although on the scalp the number will run as high as 300 and as low as 10 on the less exposed and less hairy parts of the body. These pressure spots are located at the root of each hair where there is a *hair bulb,* the stimulation of which is possible merely by touching the hair. On the hairless surfaces of the body corpuscles of Meissner are said to be the organs of pressure.

Theory of the Pressure Gradient. There are many ways in which pressure responses can be elicited: by traction, wrinkling, stretching and pulling or touching a hair. This fact suggests an explanation of pressure known as the *pressure gradient theory.* At the point of contact against the skin, or of application of force, there is set up a maximum of tension or stress which gradually descreases in the surrounding area. This *gradient* or differential in tension seems to be the condition for stimulation of pressure end-organs. Evidence in favor of this theory is found in the fact that when one immerses his body slowly in water he feels the differential in pressure at the water line, but as long as he remains still he feels no pressure beneath. Physically there is more pressure exerted against the parts of the body that are more deeply immersed, but this difference is not felt. A gradient is formed at the water line because of the sudden contrast between the air pressure against the skin and the pressure of the denser water. The gradient can also be demonstrated by placing a large box upon the skin on the arm and then a very small one so loaded that it weighs exactly the same as the large one. The smaller will seem much the heavier; the pressure gradient for the smaller object is steeper and for the larger object it is more gradual. The steepness of the gradient conditions the intensity of the pressure, and in this case one's judgment of the weight of the box.

Sensitivity to Cold. The sensitivity of the skin to cold is studied experimentally with the point of a metal stylus chilled in ice water to a temperature of 12 to 15 degrees centi-

grade (normal skin temperature 33 degrees centigrade). When a square centimeter of surface has been thoroughly explored it will be found to contain from 13 to 20 cold spots; between these spots the skin is insensitive to cold under the conditions of experimentation. It has been assumed that beneath these spots are specialized nerve endings for cold. Von Frey suggested that Krause's end-bulbs were the receptors, and in spite of the fact that his evidence was indirect and very uncertain his original suggestion of 1895 has become a tradition. But recent work by Dallenbach [8] has shown that beneath the cold spots are no specialized end-organs to be found by any methods that are at present available. Cold responses are evidently elicited through free nerve endings like those which elicit pain.

Sensitivity to Warmth. A metal stylus, heated to a temperature of 37 to 40 degrees centigrade, is used for study of warmth. In earlier investigations only 2 to 5 warm spots were found to a square centimeter of skin surface. It seems rather curious that only so small a portion of the skin responds to warmth. Why should there be so few warm spots as compared with cold and pressure? The answer at once suggests itself that heat 'spreads'! Accordingly, with fewer functioning areas than appear in case of pain, pressure and cold, there is furnished a practical sensitivity of the entire body surface to warmth. It was long supposed, as in the case of cold, that there were specialized end-organs beneath these warm spots. Von Frey suggested that they were the cylinders of Ruffini, but Dallenbach's investigation established the fact that there are as many as 30 warm spots in a square centimeter, *under none of which were there any cylinders of Ruffini.* There were undifferentiated nerve endings, pointing to the conclusion that the receptors, like those supposedly confined to pain, function for warmth as well as for cold.

Duration of the Stimulus as a Condition of Temperature Sensitivity. The skin very readily becomes adapted to moderate temperatures. Instances of gross adaptation are to be found in accustoming oneself to the cold in winter and

[8] Dallenbach, K. M., "The Temperature Spots and End-organs." *Amer. J. Psy.*, 1927, Vol. 39, 402–427.

to the heat in summer. Temporary and more sudden adaptation can be demonstrated effectively with the use of three pans of water, the right-hand pan chilled with ice, the left-hand pan heated almost hot and the middle heated only to body temperature. Immerse the right hand in the first and the left hand in the third pan; gradually the intensity of the sensations diminishes. It is possible to hold the hands in their respective positions until no difference in the temperature of the two pans can be distinguished. After at least sixty seconds have elapsed, suddenly shift both hands to the middle pan. *The water will feel warm, almost hot, to the right hand and cold to the left.* Not only adaptation, then, but contrast phenomena are to be found in temperature reactions.

High Temperature as a Condition of Cutaneous Sensitivity. When a person carelessly opens a faucet it is impossible by testing the water with the skin to tell for an instant whether he has turned on the hot or the cold. Likewise in testing hot bath water with the tip of the toe, he frequently perceives, first an icy cold, then a definite heat. The response thus elicited is known as *paradoxical cold*. The cold as such is not felt so long as the perception is that of heat. If he should begin exploring the skin with a stylus, heated to body temperature, and should gradually increase the temperature, when he reached 45 degrees centigrade, or thereabouts, he would find a rather definite change taking place from warmth to hotness. According to a conventional theory this change is conditioned by the stimulation of 'cold spots' by a temperature exceeding 45 degrees centigrade.

Theory of Temperature Sensitivity. Long before temperature spots were discovered, Weber suggested that warmth was caused by a rising temperature in the skin and cold by a falling temperature. But as a person sits before the fire, or suffers a prolonged fever, the continued warmth which he feels can not depend upon a constantly rising temperature in the skin for in time the skin would be burning! Accordingly, Hering[9] suggested an alternate theory, based upon limited adaptation. The skin at any one moment is adapted to a certain temperature which may be called *physiological zero.* A

[9] Cf. Ladd and Woodworth, *Elements of Physiol. Psychology,* 344 f.

temperature above this zero point excites warmth and a temperature below it excites cold. The physiological zero rises during warm adaptation and falls during cold adaptation. Beyond certain limits adaptation will not take place in either direction.

Waterston's Experiments on Temperature Sensitivity. In 1922, Waterston[10] attempted to relate temperature sensitivity to the blood supply of subcutaneous tissue. When he applied mustard leaf to the surface of the skin, causing dilatation of the small blood vessels beneath, he found that practically *all points were sensitive to warmth, but the response to cold was less distinct.* These findings cast considerable doubt upon Hering's theory of the physiological zero, for in terms of his theory one would expect that nerve endings, warmed by the congestion of blood, would respond more readily to cold stimuli and less readily to warm. Moreover, as Waterston points out, when every point of the surface is shown to be potentially sensitive to warmth, as well as to touch, it is doubtful whether special nerve organs and fibers should be postulated for each sensation. He suggests that in the skin there is a single sensory mechanism which can be influenced by a diversity of conditions and from which a variety of sensations can be obtained. Constant shifts in the rate of metabolism in different parts of the skin will not only account for the fact that many of the so-called 'spots' are unstable, but for the fact that there *are* any 'spots.' In other words, 'spots' may prove to be caused by an unevenness in the activities taking place within the skin. Waterston's experiments are worth repeating because his conclusions have a bearing on many of the problems which were raised by Dallenbach's study.

The Problem of Two Kinds of Cutaneous Sensitivity. It will be remembered that in vision there are two classes of light responses, one to white light and one to monochromatic light; the first yields brightness and the second yields color. In audition there are likewise two kinds of responses, namely, to noise and to tone. Growing out of casual observations

[10] Waterston, D., *Observations upon Cutaneous Sensations.* Reports of the St. Andrews Institute for Clinical Research. Vol. 1, No. 12, 1922, 183–302. Oxford University Press.

made on the recovery of wounds sustained in the Boer War, Head and Rivers,[11] and later, Trotter and Davies,[12] attacked the problem of a twofold cutaneous system. Evidence of this system seemed clear from experimental as well as from clinical results. Now when the nerve supply to a certain area of the skin is cut, the surface area becomes anaesthetic until the injured nerve regenerates; but a deep sensitivity remains unaffected. Head and Rivers thought that with regeneration of the injured nerve there returned, first *a gross sensitivity,* including pain, deep pressure and extremes of heat and cold. This was a sensitivity that did not involve localization of the stimulus, or the differentiation of 'spots' on the surface of the skin. This *protopathic sensibility,* as they called it, was in their view the primitive and original cutaneous system, whose function was to protect tissues against pathological changes and injury. Second, as the nerve supply to the affected area continued to regenerate, a *differentiated* sensibility returned, including accurate localization of pain, pressure, warm and cold upon the surface of the body. This sensibility, which they called the *epicritic,* was supposed to be of later evolutionary origin and perhaps dependent upon a different set of nerve fibers. The whole problem was attacked, in 1916, in a most thoroughgoing fashion by Boring[13] who could find no evidence for a twofold system of cutaneous sensitivity. He showed not only that previous experimental techniques had been crude and faulty, but that the observations had been superficial and inaccurate. Nevertheless, many textbooks not only in psychology but in physiology still present the epicritic and protopathic varieties of cutaneous sensitivity as facts.

In 1920, Pollock[14] published the results of his observations on several hundred World War veterans whose wounds had made different sections of the body temporarily anaesthetic.

[11] "A Human Experiment in Nerve Division." *Brain,* 1908, Vol. 31, 323–450.

[12] "Experimental Studies in the Innervation of the Skin." *J. Physiol.,* 1909, Vol. 38, 134–245.

[13] Boring, E. G., "Cutaneous Sensation after Nerve Division." *Qt. J. Exp. Physiol.,* Vol. 10, 1916, 1–95.

[14] Pollock, L. J., "Nerve Overlap as Related to the Relatively early Return of Pain Sense Following Injury to the Peripheral Nerves." *J. of Comp. Neur.,* 1920, Vol. 32, 357–378.

In certain instances pain sensitivity returned before pressure and temperature, but this could be prevented by cutting the nerve supply to adjacent areas. The pain sensitivity was assumed to be part of the protopathic sense discussed by Head and Rivers. The fact that its return was checked by cutting the nerve supply to adjacent areas pointed to the conclusion that the pain nerve supply to the adjacent areas overlapped the edges of the area supplied by the injured nerve. This overlapping was assumed to explain the early return of the pain sensitivity.

Kinaesthetic Sensitivity

History of the Problem. As early as 1832, Charles Bell [15] advanced the theory of a muscle sense based upon experimental work on animals in which he found that lesions of the spinal cord greatly affected the animal's co-ordinations. Panizza substantiated this view two years later on much the same type of evidence. In 1846, Weber [16] formulated the hypothesis that the sense of effort came from the muscles. He found it possible to judge the difference between two weights more accurately by the sense of effort involved in lifting them than by the sense of pressure obtained when he rested the weights on his skin. Not until 1892, however, were definite end-organs discovered in the muscles. Ruffini was the first to point them out and two years later Sherrington [17] experimentally demonstrated that they were receptors. Bastian [18] had previously suggested 'kinaesthetic' (from the Greek, meaning perception of movement) as a term by means of which to classify sense perceptions that depended on the motor apparatus of the body.

Sense of Innervation. Meanwhile Weber's suggestion that the sense of effort came from the muscles had not re-received wide support. Muscular movement could not, it was thought, be controlled by the muscle as is implied in the theory that the feeling of effort comes from the muscle itself. How could effort be caused by contractions already taking

[15] *The Nervous System of the Human Body.*
[16] Wagner's *Handwört.* Vol. III, 1846.
[17] *J. of Physiol.*, 1894, Vol. 17, 237.
[18] *The Brain as an Organ of Mind*, 1885, 543.

place? It must depend upon the effort to contract, made before movement commences. Accordingly, the sense of effort must have been caused by a discharge of energy from the brain into the nerves leading to the muscles. The resulting alleged experience was called the *sense of innervation.* During the early and middle nineteenth century this view was held by such prominent physiologists and psychologists as Johannes Müller, Helmholtz, Wundt and Bain; William James [19] and Hugo Münsterberg were its outstanding opponents.

Among the evidence for the innervation sense was, *first,* the statements of patients who apparently felt the effort to move a paralyzed part of the body. How could there be a sense of effort in muscles actually incapable of moving? In answer to this argument it was claimed that in trying to move a paralyzed limb, the patient actually contracted muscles in adjacent parts, the sense of effort from which he mistook as coming from the paralyzed member. *Second,* patients whose arms and legs had been amputated asserted their ability to feel movements of the missing parts. A patient studied by Wier Mitchell claimed to feel his amputated hand open and shut and his thumb move across the palm to the little finger. Many similar observations had been made, but the opponents of the innervation theory insisted that they were illusions based upon stimulations of the stump, and pointed out that the misperceptions disappeared after the nerve supply of the stump had become thoroughly readjusted. It is a commonplace fact that when nerves are regenerating, a process that may require several years, there frequently occur paradoxical perceptions of contact and movement which are referred to adjacent parts of the body. These illusions are evidently traceable to activities of the regenerating fibers and nerve endings.

Third, the size-weight illusion was regarded as evidence for the innervation sense. When two boxes are lifted, the one large and the other small, but actually weighing the same, the smaller seems much the heavier. It was thought that on seeing the large box more effort is expended in preparing to lift it than is actually necessary. As a consequence the box is raised with unexpected ease and by contrast feels abnor-

[19] *Principles of Psychology,* 1890, Vol. II, 493 ff.

mally light; conversely, in case of the smaller box, little effort is expended to lift it and the actual weight of the box pulls the hand downward. More effort is required than was expected, hence the box is judged heavier than its actual weight. This was the easiest of the three arguments to answer. When any one prepares to lift an object he contracts his muscles, hence the feeling of effort is produced *at the muscle.* In fact to lift a heavy object like an hundred pound sack of sugar, he tenses his arms, trunk and legs in advance. It is a simple matter to prove that if the muscles were relaxed the sack of sugar would never be lifted. *It is quite clear, therefore, that the feeling of effort comes with, not before, the contraction of the muscles.*

Conditions of Kinaesthetic Sensitivity. The following conditions of kinaesthetic sensitivity have been demonstrated: (1) Contraction of the muscle cell and subsequent excitation of proprioceptors lying within the cell itself; (2) strain and pull upon the tendons which are richly supplied with spindles and corpuscles (Pacinian corpuscles, corpuscles of Ruffini, spindles of Golgi) and (3) sliding and rubbing of the surfaces of articulation at the joints in the linings of which are various end-organs. Upon being stimulated through these three channels the human being constructs perceptual configurations of muscular movement, bodily position, resistance and weight.

The Rôle of Kinaesthesis in Behavior. No group of end-organs functions so continuously and in so great a variety of situations in life as the kinaesthetic; muscles are always functioning. A person may be deprived of eyes and ears; his sense of smell may be defective, in addition; but there is never complete loss of kinaesthesis (perception of muscular movement and tension). Indeed, with partial loss of kinaesthesis there is correlated an abnormal disturbance of behavior. Persons suffering from *locomotor ataxia,* a disease of the spinal cord, are able to walk only with great difficulty by means of canes, and by closely watching their feet; unsupported and with eyes closed they are unable to keep from falling. The trouble lies in a degeneration of the paths in the cord that connect the muscles of the legs with the brain, thus cutting off

the effects of proprioceptive stimulation, and impairing muscular co-ordination.

If every performance is executed by the organism-as-a-whole, muscles obviously function to some extent in all kinds of responses. An inventory of human reactions in which kinaesthesis is found confirms this view. The preponderance of motor activity in emotive behavior is so obvious that it need not be discussed, and of course wherever there is a contraction in the skeletal muscular system there is kinaesthesis. Intelligent behavior involves kinaesthesis throughout, although in certain isolated instances its presence is not always noticed specifically. It is merely perceived as 'feeling.' It is found in recognizing, in making comparative judgments and in choosing.

Kinaesthesis is involved in visual imagery. When a near object and then a far one are visualized there occur changes of accommodation and convergence as in actual vision. Why not? Visualization is an effort *to see* an object not present. Hence when thinking involves visual imagery it also contains kinaesthesis. Moreover, much of thinking consists of vocal-motor imagery and this imagery involves incipient movements of the speech muscles. The movements can be recorded, and their amplitude varies directly as the definiteness with which the words are imaged. While several investigations of verbal imagery fail to show a correlation between definite movements and particular words or letters, the prediction may be hazarded that more refined methods will show a more precise relationship. Thinking occurs also in terms of conscious or motor attitudes: acceptance, rejection, doubt, belief, anticipation, expectancy, certainty, uncertainty, assurance and many others. In each case kinaesthesis is involved. It is present in localizing sounds, in localizing contacts on the skin and in perceiving tastes and smells.

Because kinaesthesis is an essential condition of conscious behavior, it should not be concluded that the latter is exclusively explained or defined in terms of the former. There are many essential conditions of behavior none of which is sufficient in itself. If any essential condition of an event is eliminated, the event does not take place. If all incipient

movements of the individual were inhibited no mental processes would take place; yet all processes are not to be identified with kinaesthesis. Similarly, if there were no flour there would be no cake, although cake is something more than flour!

Organic Sensitivity

Conditions of Hunger. After one has eaten there occur at regular intervals gentle peristaltic contractions of the stomach wall which aid in passing the partly digested food through the *pylorus* (from the Greek, meaning gate-keeper) into the little intestine. A few hours after the contents have been removed from the stomach sharp periodic contractions of the stomach wall commence. Precisely under what conditions they begin is not known but evidently one condition is the state of the mucous linings of the stomach, and another the degree to which the stomach has contracted from being empty. Whatever the inciting cause, the stomach wall contracts periodically for two or three days unless food is taken. After that time, according to the results of fasting experiments, the contractions cease.

Cannon[20] was able to correlate these contractions with the subject's perception of hunger pangs. The subject swallowed a small rubber balloon attached to a stomach tube; then the balloon was inflated and the stomach tube attached to a manometer which actuated a cork float and a recording lever. Whenever the subject felt a hunger pang he pressed an electric key, thus actuating another writing lever. The records of muscular contractions coincided with the subject's reports of hunger pangs. It has also been found that contractions of the esophagus, as well as the stomach, produce hunger sensations. Carlson[21] was able directly to observe stomach contractions in a patient whose stomach had been opened and a tube inserted. The patient had accidentally swallowed some caustic soda and the resulting adhesions had closed the esophagus. After he had chewed his food it was necessary to place it into his stomach through the tube.

[20] *Op. cit.*

[21] Carlson, A. J., *The Control of Hunger in Health and Disease*, 1916.

Sensitivity of the Esophagus. Almost nothing of a strictly scientific character was known about the sensitivity of the esophagus until Boring's investigation in 1915. Boring[22] swallowed a rubber tube to a known length and then poured stimulating substances through it; thus he knew exactly where the substances first came in contact with the walls of the esophagus. The stimuli consisted of warm and cold water, weak acids, peppery liquids and electric shocks. To provide the electric shocks a rubber tube was swallowed near the end of which were several concentric, brass rings of the same diameter as the tube. Wires led to these rings through the inside of the tube. In this way Boring was able to send an electric current of any desired strength from one ring to another through the adjacent wall of the esophagus. He found that the most sensitive region lay in the throat where each stimulus could be localized fairly definitely. There was great difficulty, however, in localizing stimuli along the middle section under the sternum. It generally happened that these latter stimulations seemed to come either from the throat or the stomach. It is possible that the greater sensitivity of the upper and lower ends of the esophagus depends upon the greater mobility of the adjacent parts of the body. (Cf. fineness of the two-point threshold on the more mobile parts of the body.)

Miscellaneous Organic Responses. Experimental results indicate that the stomach itself is not sensitive to temperature stimuli. The warmth and cold sensations felt immediately after drinking is probably a matter, respectively, of the irradiation of heat to adjacent sensitive areas on the surface of the body and of the absorption of heat from them. When the water content of the mucous linings of the soft palate and adjacent parts diminishes to a certain point, nerve endings of the membranes are stimulated, giving rise to thirst. Thirst as well as hunger incite general bodily tensions which are not relieved until the individual's needs are satisfied. Much that is popularly ascribed to hunger and thirst is, therefore, a kinaesthesis caused by these general bodily tensions.

[22] Boring, E. G., "The Sensations of the Alimentary Canal." *Amer. J. Psy.*, 1915, Vol. 26, 1–57.

Referred Pains. Certain morbid conditions of the internal organs give rise to referred pains. Disorders of the stomach may condition pains in the forehead, temples and side of the head toward the top (parietal region). Intestinal troubles often give rise to pains at the side, top and back of the head. (The side of the head is called the temporal region; the back is called the occipital region.) Abnormal conditions of the ovaries and testes produce pains in the occipital region. Usually, however, the place on the body to which a pain is referred lies near the affected organ. Over a period of years Head [23] made a series of investigations of these little understood phenomena and came to the conclusion that the internal organs possessed a low sensitivity to pain but that their nerve connections were closely associated with those centers in the brain that functioned in the perception of surface pains. Accordingly, Head formulated the following law: "When a painful stimulus is applied to a part of low sensibility (internal organ) in close central (brain) connection with a part of much greater sensibility (surface of the body) the pain produced is felt in the part of higher sensibility rather than in the part of lower sensibility to which the stimulus was actually applied." [24] In his theory the misreference is traceable to diffusion in the nerve centers. Pottenger [25] points out that the nerve supply of the internal organs originally grew out, in the embryo, from various segments of the spinal cord region. This nerve supply retains its connection with the region from which it sprang, but approximately these same regions of the cord send fibers to external muscles and to the skin of the body. Hence the location of the referred pain depends upon the segmental relationship that developed early in the life of the embryo.

Referred pains are probably more than a misreference. Nerve cells in the area of the cord adjacent to that which receives impulses from the diseased organ become hyper-irritable as a consequence of which very slight stimulation affects them. These areas subserve those parts of the body in which the re-

[23] Head, H., *Brain*, Vol. 24, 1901, 345.
[24] *Brain*, Vol. 16, 1893, 127.
[25] Pottenger, F. M., *Symptoms of Visceral Disease* (2d ed.). St. Louis: Mosby Co., 83.

ferred pains are localized. It may be conjectured that very slight stimulation of these parts, like barely touching the skin or pressure stimulation from the circulation of the blood, are then sufficient to produce pain.

General Summary of the Simpler Sense Perceptions

Chemical and Mechanical Senses Contrasted. While it is true that mechanical and chemical modes of stimulating the sense organs are similar in the last analysis, it is nevertheless convenient and profitable to divide the sense departments into two classes, the one stimulated mechanically and the other chemically. The chemical senses begin with pain as the simplest, the end organs for which are so undifferentiated that they will respond to a great variety of stimulations including mechanical contact. Again, because of the undifferentiated condition of the receptors, the resulting sensory processes are simple and undifferentiated; the latter exhibit no adaptation, contrast, neutralization or mixture. While pain exhibits various qualities such as ache, sharp prick, knife-edge pain and itch, the same quality exists throughout under differing conditions of space, time and intensity.

A Theory of the Temperature Senses. Next in order of complexity are warm and cold sensitivity. It can not be stated whether contrast effects in temperature come from the same or from different nerve endings. It has always been supposed that warm and cold receptors were quite different in structure and were located in different positions in the skin. Since Dallenbach's and Waterston's studies the problem arises whether a cutaneous 'spot' is the product of a single end-organ or a host of them. Indeed, the actual rôle of the end-organ is unknown. It can be conjectured, however, that the nerve endings for warmth and cold are very slightly differentiated from those of pain, that they are the same for warmth and for cold, that they respond to very low intensities in one way and to high intensities in another, as is likely with the end-organs of vision in case of black and white. Cold, like black, is a positive phenomenon psychologically, but a negative phenomenon from a physical standpoint. It may be suggested

also that contrast depends upon adaptation much as in vision, but that the temperature end-organs are not sufficiently delicate and differentiated to produce after-imagery. Likewise, they are not sufficiently differentiated to yield phenomena of neutralization and mixture. Supposedly, hotness is intense warmth, not, as once thought, a fusion of warmth and cold; paradoxical warmth and cold are induced contrast phenomena produced at the margins of the stimulated area, where the paradoxical sensations are often felt.

It may be supposed that warm spots are fewer than cold spots because higher intensities of stimulation, through conduction, involve a greater number of nerve endings in the production of a single response than low intensity stimulations. The mode of stimulation for warmth is the absorption of heat by the end-organ; low intensity stimulations involve a subtraction of heat from the end-organs. The subtraction is confined to a small area, hence the relatively greater frequency of cold spots. According to this theory the colder the stimulus the more frequent and smaller the spots within a given area; the warmer the stimulus the fewer and larger the warm spots.

A Theory of the Roundness of 'Spots.' An interesting problem arises in connection with cutaneous 'spots.' Other things being equal, they are round! Why should they be round and not square? The same answer suggests itself that explains why drops of water are 'round;' the latter are 'round' because of the approximate equality of air pressure exerted upon them from all sides. (Drops of mercury are better examples.) The roundness illustrates the conditions of least action, for as long as there is equality of pressure exerted upon the drop from every direction, the drop will fit itself directly to this particular pressure pattern. When a single nerve ending or a group of nerve endings is stimulated, it may be presumed that the resulting pattern of nervous energy adjusts itself to the patterns of equal potential around it either in the skin or in the central nervous system or both. If this is true we might expect the 'spots' to appear round. A similar explanation may be suggested for the fact that when a figure is pressed against the skin, like a small square or triangle, the object appears circular unless the entire contour of the stimulus-

object is felt very distinctly. It also explains why a small, several-sided polygon with sides too short to be distinguished, feels perfectly round.

Comparison of Chemical and Mechanical Senses, Continued. The next sense department in order of complexity is taste, a chemical sense the end-organs of which are differentiated sufficiently to condition *four instead of two* qualities. Adaptation is easily produced and more contrast effects occur than in the case of temperature. There is evidence of neutralization, but an imperfect development of antagonistic reactions; and as yet no mixture and no after-imagery.

Smell is next in order of apparent differentiation of the end-organs. There are adaptation and contrast as before, but more neutralization than in the case of taste, and in addition, definite evidence of mixture. There are also more antagonistic qualities in smell, which we may regard as the evolutionary prototypes of complementaries in vision. But differentiation is imperfect and incomplete, and there is consequently no definite after-imagery. Lastly, in the chemical series, is vision in which adaptation, contrast, neutralization and mixture are observable at their maximum, together with after-imagery, which is a highly evolved form of contrast.

In the other group of sense departments, the mechanical, these various phenomena are lacking. In the case of kinaesthesis it is highly doubtful that adaptation occurs, and there are certainly no true contrast phenomena. When one object seems lighter than another 'by contrast' it is caused by the suddenness with which the object is lifted in the one case and by the retardation of lifting movements in the other. In the mechanical sense department of the next degree of complexity, namely pressure, 'adaptation' is a matter of ignoring the stimulation. We say that we adapt to our clothes and yet if we choose we may attend to any part of our bodies and feel the pressure. If extremely light objects are perceptible only for a short time, it is probably a matter of mechanical adjustment in the skin and not an adaptation of the end-organs. Accordingly, there is little if any genuine adaptation to pressure. Next come the vestibular organs which, like the kinaesthetic, yield no true adaptation and contrast phenomena. And finally,

there is audition where again all of the characteristics of a chemical sense are lacking. The adaptation often mentioned in case of hearing is a matter of eliminating sound stimuli from the pattern to which the observer is responding. At will he can hear any sound to which he has become 'accustomed' and ordinarily does not notice, just as he can at any time become aware of his breathing. These facts do not mean that when the subject is not perceiving sounds and pressures he is having unnoticed sensations. They mean that at certain times and not others he is responding to auditory and cutaneous stimuli.

A Configurational Interpretation of Sensory Processes. Contrary to the prevailing tradition that a single nerve ending always yields a definite, discrete sensation, we are led by the work of Helson, Dallenbach and by the numerous discoveries of the configurationists, to regard the sense organ as a factor in the formation of *patterns*. The 'sensation' from a single organ is a perceptual pattern; 10,000 sense organs yielding the same quality and functioning at the same time produce exactly as simple a sensation, namely, a perceptual pattern. This pattern is not composed of so many separate sensations produced by so many separate end-organs. It is a pattern based, to be sure, upon a given number of nerve impulses because a given number of end-organs are functioning, but the effect of these nerve impulses is that of causing shifts of potentials from one part of the brain to another. Once brain action begins there is no representation of separate end-organs; instead, there is a representation of the stimulus-pattern as a whole. The brain pattern is formed in part, so to speak, by the stimulus-pattern.

In the configurational view, if 'consciousness' is to be considered a separate aspect of behavior, it is, in the beginning, an undifferentiated, a relatively homogeneous phenomenon. It is not composed of discrete sensations which subsequently fuse into larger wholes. On the contrary, the development of any process is exactly the reverse, a differentiation from the whole. The configurationists speak of the appearance of a particular sensation as the emergence of a 'quality' from a 'ground.' Specialized sensations are, therefore, the end stages

of a particular maturation process, not the beginnings. The infant's first experiences are probably not visual, tactual or auditory, but diffuse, 'blanket' processes out of which these various types of qualities gradually appear by an individuation process. The adult in novel situations notices less detail than the trained observer. Let an adult glance through a microscope at a histological slide and he sees nothing but an undifferentiated mass of color, while the laboratory technician sees a wealth of detail. The author was once taking a general anaesthetic and his last experience before falling completely asleep was of a homogeneous field of vivid, pinkish light, occasioned when the physician opened the subject's eyes to test his pupillary reflex. The anaesthetic had reduced the subject's mental processes to an undifferentiated condition which was presumably analogous to the first experiences of the infant.

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CHAPTER XVI

THE NERVOUS SYSTEM IN ITS RELATION TO BEHAVIOR

Structure of the Nervous System

Introduction. We are ready to take the final step in the reduction of the human organism from a social to a biological creature, a step which involves us in a study of the nervous system. Facts about the nervous system are the last abstractions to be made before the human being is ready for a final analysis by the chemist and the physicist. In discussing the structure and functioning of the nervous system, as such, we shall be taking behavior for granted, because the problems then under investigation deal only with anatomical and physiological facts. Our procedure will at times involve a dissection of the organism and of course the assumption that the organism is no longer intact. Nevertheless, the facts that will be considered help us in understanding the behavior of the organism-as-a-whole; indeed, *they reveal in a striking way the principles upon which our concepts of behavior are based.*

The Nerve Cell. The nervous system is largely composed of elongated conductors known as nerve cells or *neurons.* These neurons vary within wide limits in their appearance; some are only a fraction of a millimeter long; others are three feet or more in length; they are all microscopic in width. In general there are two types of neurons, *unipolar* and *bipolar.* In case of the bipolar cell (also called multipolar, see Figure 61), conduction begins in the dendrite or receiving end and terminates in one or more of several discharging terminals called *end-brushes.* The dendrites are short, elaborately arborized structures close to the *cell body.*

From the cell body there extends an elongated fiber, an *axon,* which sends out branches or *collaterals.* The axon and collaterals terminate in the end-brushes.

The unipolar (sometimes called bipolar) cell consists, first, of a long fiber, one end of which receives the impulse and the

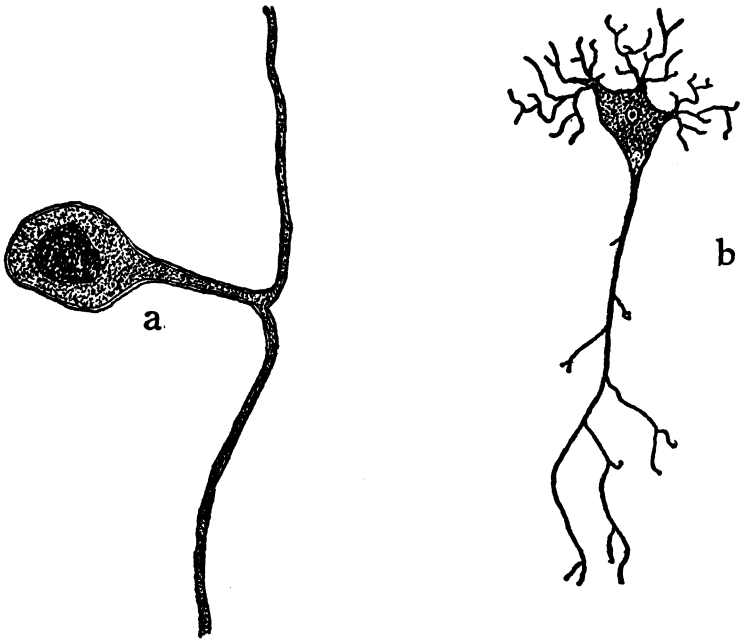


FIG. 61. TYPICAL NEURONS.

a. The central portion of a spinal ganglion cell (sensory) connecting the sense organs of the body with the spinal cord. These cells have no true dendrites but in each cell one of the long fibers, a portion of which shows in the drawing, connects with a receptor in the skin or muscle, and functions as a dendrite. The other long fiber, which is continuous with the first, extends into the spinal cord where at one level or another it terminates. The route to the brain is then continued by additional cells. The cell body of the spinal ganglion cell lies in a spinal ganglion just outside the spinal cord.

b. A typical neuron found within the central nervous system. Some of these neurons have extremely elaborate dendrites and long axons extending down into the spinal cord from the cerebral cortex. This cell may be 'motor' or 'association.' We have called *a* the unipolar type and *b* the bipolar type of cell.

other end of which discharges it. It consists, second, of a cell body connected with the long fiber by means of a short stem. The cell body, therefore, lies a little to one side of the main path of conduction. Beyond the cell body the fiber functions as an axon, branches into collaterals and leads to its arborized terminus. This cell is sometimes called the T-type and is a

sensory cell since it conducts impulses to the spinal cord from the receptors in the skin and muscles of the body. It is called unipolar because from an anatomical standpoint it is lacking in a true dendrite.

A Superficial View of the Nervous System. The nervous system is composed of elaborate chains of elongated cells arranged end to end in such fashion that a circuit is formed between the receptors of the body through the brain and spinal cord to the glands and muscles. In general the functions of this circuit are to connect all parts of the organism with the outside world and to bring all parts of the organism into relationship with each other.

Fibers converge from the receptors of the body into small bundles of *nerves,* then into larger ones, leading from the body into the spinal cord over spinal nerves, and from the head directly into the base of the brain over the *cranial nerves.* All nerves that conduct from sense organs to the central nervous system are *sensory nerves.* Other fibers extend from the base of the brain to the muscles of the head also over cranial nerves, and from the spinal cord to the muscles of the body. All nerves that conduct from the central nervous system to the muscles are known as *motor nerves.* A single large nerve, like the sciatic in the leg, contains hundreds of thousands of fibers. Like other nerves, it is white in appearance.

White material (or white matter) of the nervous system, whether central or peripheral, is composed of fibers each of which is covered with a white fatty substance, the *myelin sheath.* Within the brain and spinal cord are ganglia or nuclei composed of *gray* matter, that is, dendrites, cell bodies and *unmyelinated* axons. All *synapses* are therefore in the gray matter since the synapse is the membranous juncture between the end-brush of one neuron and the dendrite of another.

The nervous system is *bilateral;* sensory nerves from the left half of the body find their way to centers in the right half of the nervous system, and motor nerves originating in the left half of the nervous system ultimately connect with muscles on the right half of the body.

Sketch of the Evolution of the Nervous System. The simplest form of nervous system, found in certain jelly-fishes,

consists of a diffuse network of nerve cells and fibrils distributed through other structures of the body. All parts of the net are connected so that it forms a common and continuous medium between the receptors and the contractile tissues of the organism; the different cells connect with each other *by actual union.* This simple nervous system conducts from any given receptor to all parts of the body at the same time. Next in order is the nervous system of the flatworm in which is found the first stage of a centralized plan, the formation of a central co-ordinating ganglion. Movement of the whole body at once is possible with the ganglion removed, but the movement is slow.

In the earthworm there is found the simplest centralized type of system; the body is divided into segments each of which is supplied with its own ganglion, and the ganglia are connected with each other by heavy nerve strands. At the head-end is a large, cerebral ganglion or primitive brain. By the time higher forms of animal life are reached the segmented ganglia have evolved into a spinal cord, and the cerebral ganglion has become a brain composed of several interconnected ganglia. These ganglia, not being anatomically separate structures, are known as *nuclei.* In the meantime the network type has not altogether disappeared. In the earthworm there are many cells of the nerve-net type; in vertebrates, including human beings, the walls of the heart, stomach, intestines and blood vessels still contain a similar kind of nerve supply, completely fused. Cells of the ganglion type of system do not unite, but are separated by membranous junctures which we have already defined as synapses.

In the lower organisms with diffuse nervous systems behavior is relatively unspecialized. A single stimulus will produce a general response of the whole organism with the part nearest the stimulus affected most. The earthworm with its segmented nervous system is capable within limits of executing *part activities,* or in other words, of contracting the muscles of a single segment independently of other segments. It is also capable of making movements that progress from one end of the body to the other, segment by segment. And finally, it can move the whole body at one time.

Wherever there are specialized structures working together as in the case of segments in the earthworm, the nervous system is essential in co-ordinating its various parts. In the human being, whose specialized structures are more complicated and whose part-activities are more elaborate, a centralized nervous system of a more complicated pattern is necessary. For example, the human being moves his arms, head, fingers and legs relatively independently. *Yet these movements occur under the direction of the organism-as-a-whole or they are in no way relevant to the behavior of the organism-as-a-whole.* In other words, the nervous system as a total pattern controls the activities of its parts.

Recalling what was said on page 264, that the whole explained its parts better than the parts explained the whole, the physiological basis for that assertion can now be understood. The undifferentiated, simple organism came first, before specialized parts developed. The nervous system was a homogeneous, diffuse network which functioned as a whole or not at all. Out of total but simple organisms there evolved creatures with specialized parts, all of the parts, however, functioning with reference to the whole. As the total organism became more complicated and its parts more specialized, a centralized nervous system became necessary for the maintenance of unity and organization.

Evolution of the Brain. When the vertebrates are reached the central nervous system is seen evolving through a series of stages in which one specialized system is superimposed upon another. The oldest of these is the *fundamental system;* it consists of sensory cells that carry impulses from the receptors of the body to the central ganglia of the spinal cord. In the ganglia are central fibers and synapses which connect the sensory cells with outgoing or motor cells. The latter lead out from the connecting cells to the muscles of the body. In the vertebrates this system also includes ganglia, together with sensory and motor fibers, in the base of the brain. This part of the system connects the receptors of the head with the muscles of the head and body.

Superimposed upon the fundamental system are several others, all of early origin in the animal scale. First, there is

the *mesencephalic* or *tectal system,* representing the latest evolutionary development of the nervous system in fishes, amphibia, reptiles and birds. It consists chiefly of special eye and ear-brains, the *corpora quadrigemina,* which connect the eye and ear with the muscles of the head and body by means of routes to the spinal cord.

Second, there is the *cerebellar system* consisting of the *cerebellum* and several nearby ganglia lying at the base of the brain. This system connects the organs of equilibrium with the muscles of the body; it brings the proprioceptors of the body into relation with motor nerves leading back to the muscles, and joins the receptors of the head with the muscles of the body. It maintains bodily tonus and functions in the control of movements that are automatically made in orienting the body to gravity. Obviously in birds, where balancing movements are of special importance in flight, the cerebellar system plays a large rôle.

Third, there is the *archipallial* (old brain) system which is of special importance in fishes and is concerned largely with the sense of smell. It consists of several smell-ganglia, scattered in various parts of the brain, and a bridge of fibers, the *fornix,* connecting certain of these ganglia with each other.

During the course of evolution there was superimposed upon these three intermediate systems a new brain, the *neopallial system,* which constitutes the bulk of the brain in higher vertebrates. It consists of two large cerebral hemispheres, the outside layer of which is gray matter called the *cerebral cortex.* Beneath the cortex is a mass of white matter, composed of myelinated fibers some of which link one part of the cortex with another of the same hemisphere, others of which associate one hemisphere with the other. These are called *association fibers.* Then there are two sets of *projection fibers,* first the sensory, bringing lower nuclei (thalamus) into relation with the cortex and spinal cord and second, the motor, connecting the cortex with nuclei in the base of the brain and with the spinal cord.

Gross Anatomy of the Brain. These systems may be considered a unified whole, whose outlying parts are the sensory and motor nerves, and whose central parts are the brain

and spinal cord. The brain as a whole is called the *encephalon.* It is conveniently divided into sections, the name for each of which signifies its position with respect to the whole. Commencing at the forward end there is, *first, the rhinencephalon,* or nose-brain which is part of the archipallial system. In man it consists of small olfactory bulbs on the ventral surface of the cerebral hemispheres, and of tracts leading through the bulbs from the nose to the olfactory 'centers' in the cortex (hippocampal lobe). *Second,* there is the *telencephalon,* the *endbrain,* consisting of the cerebral hemispheres. Inside the hemispheres are: *first,* narrow, winding canals called the *lateral ventricles* which are filled with *cerebrospinal fluid, second,* the cortex, together with the association and projection fibers already mentioned, and among others, two masses of gray matter, the *lenticular* and *caudate nuclei.* Proceeding toward the base of the brain, there is, *third,* the *diencephalon* or interbrain which consists of (a) the *thalamus,* (b) the *hypothalamus* (pituitary gland and mammillary body, the latter an integrating center for smell, belonging to the archipallial system), (c) the *metathalamus,* composed of the so-called *geniculate bodies,* and (d) the *epithalamus* (pineal gland and *habenula,* the latter another smell co-ordinating center belonging to the archipallial system). In the center of the interbrain is the third ventricle. The telencephalon and diencephalon together compose the *prosencephalon or forebrain* (Figure 62).

Still farther down there is the *fourth major* section, namely, the *mesencephalon* or *midbrain.* This, like the diencephalon, is fully visible only as the cerebral hemispheres are dissected away. The midbrain is composed of the corpora quadrigemina which, as stated above, belong to the tectal system, together with the *cerebral peduncles* (stalks), consisting largely of fibers leading down to the spinal cord from the cortex. Passing through the midbrain is a canal called the *aqueduct of Sylvius* which connects the third and fourth ventricles. Below the midbrain is the *fifth* division, the *metencephalon* or *hindbrain,* of which the cerebellum is the most conspicuous part. It contains also a bridge of fibers called the *pons varoli;* these fibers for the most part connect one

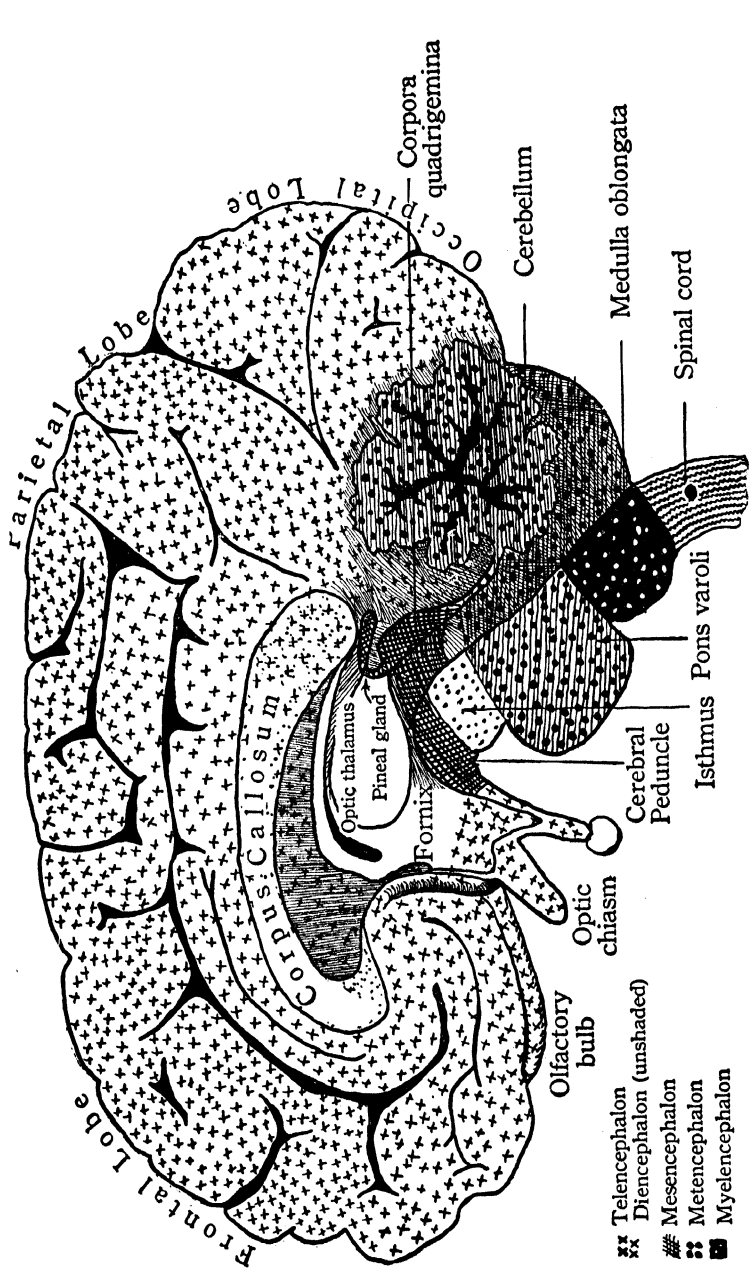


FIG. 62. RIGHT CEREBRAL HEMISPHERE OF THE HUMAN BRAIN VIEWED FROM THE LEFT.

side of the cerebellum with the other; and beneath them are several nuclei. *Sixth* and finally, there is the *myelencephalon* or *afterbrain,* which is composed largely of the *medulla oblongata.* It contains, (1) various nuclei having to do with certain receptors and muscles of the head, and (2) the 'vital center' which controls breathing and heart action, the center of the vagus nerve (see page 215). The hind and afterbrains, taken together, constitute the *rhombencephalon* or *rhombic* brain.

The Cranial Nerves. The receptors and muscles of the head, and to some extent of the neck, are accommodated by twelve pairs of cranial nerves that radiate from the ventral surface of the brain. The names and functions are given in Table XIII.

TABLE XIII

THE CRANIAL NERVES

Nerve	Function
1. Olfactory	smell; connects olfactory region with rhinencephalon.
2. Optic	vision; connects retina with corpora quadrigemina and external geniculate bodies.
3. Oculomotor	carries fibers to the ciliary muscle and iris; innervates four of the six external muscles of the eyeball.
4. Trochlear	goes to one of the six pairs of eye muscles (superior oblique).
5. Trigeminal	supplies skin of the face, sensitive surfaces of the eyeball, nose, front of mouth; innervates muscles of mastication.
6. Abducens	goes to the last of the external eye muscles (external rectus).
7. Facial	main motor nerve of the face; goes to muscles of facial expression and to salivary glands; carries small bundle of taste fibers from first third of the tongue.
8. Auditory	connects cochlea and organ of equilibrium with base of the brain.
9. Glossopharyngeal	connects receptors back of tongue and throat with the brain; carries taste fibers from rear of tongue.
10. Vagus	cranial division of autonomic nervous system. (See page 215.)
11. Spinal accessory	innervates certain muscles at the back of the neck.
12. Hypoglossal	innervates the tongue.

The Spinal Cord. The spinal cord, as we have seen, receives fibers from the receptors of the body, sends fibers to the muscles and connects with the brain centers above. These fibers connect with the body over spinal nerves which split immediately before entering the cord; one half of the nerve carries sensory fibers into the spinal cord over the *dorsal root* (back) and the other carries motor fibers from the cord to the muscles over the *ventral root* (front) (see Figure 63). The cell bodies of the entering sensory cells lie outside

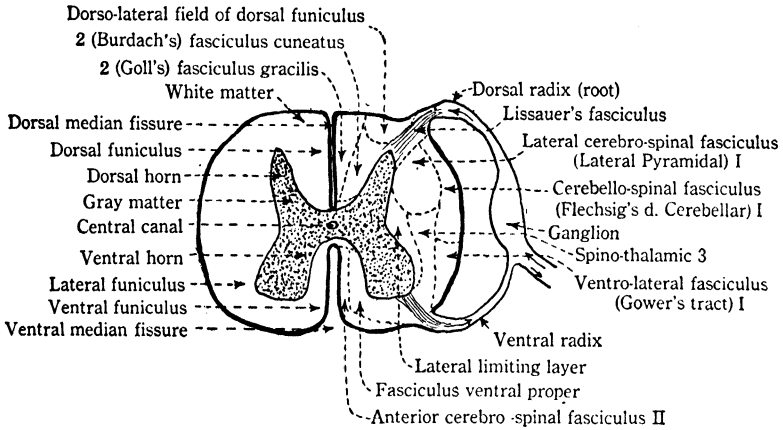


FIG. 63. CROSS-SECTION OF THE SPINAL CORD.

The major ascending and descending tracts are indicated. The three groups of ascending tracts mentioned in the text are numbered 1, 2 and 3. They are (1) the Cerebello-spinal fasciculus or Flechsig's tract and the Ventro-lateral fasciculus or Gower's tract; (2) the Fasciculus cuneatus or column of Burdach and the Fasciculus gracilis or column of Goll; (3) the Spino-thalamic tract. The descending tracts that are shown are (I) the crossed pyramidal or Lateral cerebro-spinal fasciculus and (II) the uncrossed pyramidal or Anterior cerebro-spinal fasciculus. Fasciculus means a bundle of fibers, often used as a synonym for tract; funiculus means a major division of white matter. Radix means root.

the spinal cord, in the dorsal root. A typical cross-section of the spinal cord would reveal a mass of gray matter on the inside and a layer of white matter on the outside. The gray matter consists of dendrites, cell bodies and axon terminations. It joins one level of the cord with another and links the higher brain centers with motor cells leading to the muscles. It also connects sensory and motor neurons at all levels of the cord, bringing into relation receptors and muscles on the same and on opposite sides of the body.

The white matter consists of ascending and descending fibers, arranged in *tracts.* The ascending are the sensory tracts and may be divided into two groups, the proprioceptive and exteroceptive. The former has three divisions: *first,* fibers from the cord to the cerebellum, connecting the receptors of the body muscles with the cerebellum (tracts of Flechsig and Gowers); *second,* fibers from the cord to the brain stem connecting muscles of the body with the medulla (tracts of Goll and Burdach); *third,* fibers to the thalamus connecting the muscles of the body with the cortex (spino-thalamic). The third route is supposed to mediate perceptions of posture, tension and movement. The impulses of the first two divisions are said to have nothing to do with conscious behavior, but merely with the reflex maintenance of balance and with the tonus of the muscles. The other group includes two divisions, one leading to the medulla and the other to the thalamus. The latter tracts carry impulses to the thalamus from receptors of pressure, temperature and pain. At the thalamus, connections are made with the cerebral cortex.

The major descending tracts are the *crossed* and *uncrossed pyramidal,* composed of fibers of neurons whose cell bodies are in the cerebral cortex (motor area). Their main terminals connect, in the ventral (front) gray matter of the cord, with motor neurons to the muscles. We may mention three minor tracts: *first,* a tract from the midbrain to the spinal cord (rubro-spinal), connecting the cerebellum and thalamus with the muscles of the body; *second,* a tract which connects the eye with the muscles of the body (tecto-spinal tract); and *third,* a special tract linking the organ of equilibrium with the muscles of the body by way of centers in the medulla.

Connections between the Retina and the Brain. The connections between specific sense organs of the body and the brain are extremely complicated, especially in case of the visual and auditory receptors. In tracing out these connections it is therefore helpful to number each cell, beginning with the receptor. In case of vision the rods and cones are dendrites of cells number 1 and compose what is known as the ninth layer of the retina (Figure 64). The cell bodies of these neurons lie in the seventh layer and their axons terminate

in the sixth. Cells number 2 begin in the sixth layer where their dendrites make connections with the axons of cells number 1. Their cell bodies lie in the fifth layer and their axons terminate in the fourth. Cells number 3 commence in the fourth layer; their bodies lie in the third and their axons lead

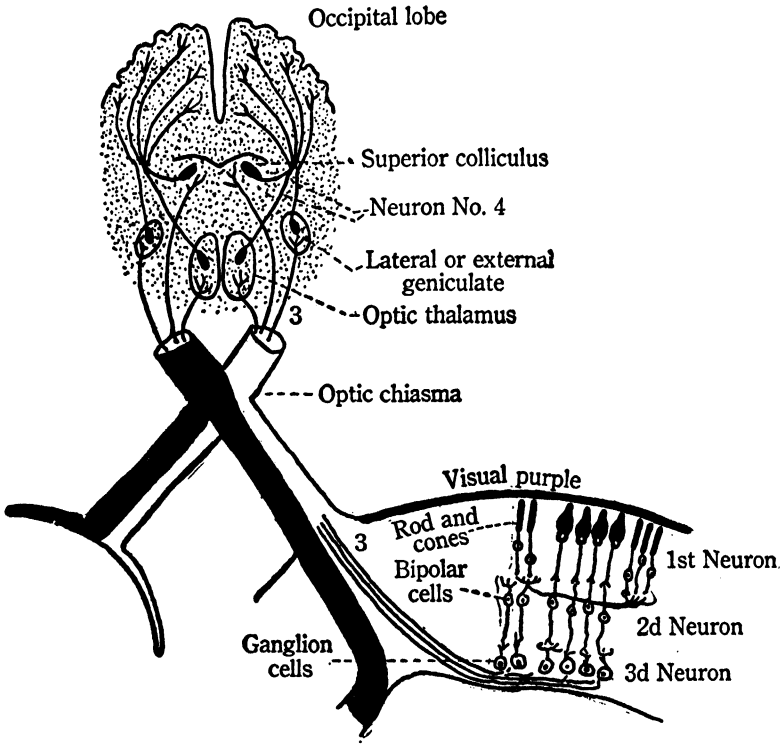


FIG. 64. CONNECTIONS BETWEEN THE RETINA AND THE BRAIN (Schematic).

Note the positions of the neurons numbered from 1 to 4. The *Superior colliculus* is another name for one of the anterior *corpora quadrigemina*. The *Lateral* or *external geniculate* body is considered part of the thalamus which contains about twenty different nuclei. The exact location of the visual purple is in doubt.

through the second and first layers to the optic disc, where they congregate to form the optic nerve. The optic nerve, then, consists of axons of the third visual cell. Fibers of this nerve terminate in at least three regions: in the anterior corpora quadrigemina, in the *external geniculate body* and pulvinar of the thalamic region. Cells number 4 begin with den-

drites in the three regions just named and send their axons to the posterior part of the cerebral cortex, the *cuneus.* This involves the so-called visual area.

Fibers from the *fovea* of each eye lead to *both* visual areas. The right half of each eye connects with the left visual area and the left half of each eye with the right visual area. This means, of course, that somewhere along the line there is a crossing; the crossing occurs at the *optic chiasm,* just before the nerves enter the brain. The optic nerve carries fibers connecting the retina with centers in the midbrain that assist in the co-ordination of eye-movements; it also carries fibers leading from one retina through the chiasm back to the other retina. And finally, it carries fibers leading from one side of the thalamus to the chiasm back to the other side of the thalamus.

Connections between the Cochlea and the Brain. The hair cells of the cochlea are auditory cells number 1, which have no axons. Dendrites of cells number 2 twine around the bases of cells number 1; cell bodies of number 2 lie in the body cavities of the lamina spiralis (page 407) and their axons terminate in nuclei in the pons. Dendrites and bodies of cells number 3 are in these pontine nuclei and the axons extend to another part of the pons, to the inferior corpora quadrigemina, and to the internal geniculate body of the thalamus. Then cells number 4, with dendrites and bodies in the corpora quadrigemina and thalamus, send their axons to the lateral regions of the cerebral cortex.

The Lobes and So-called Areas of the Cortex. The cerebral cortex is richly supplied with folds or *convolutions* (gyri) with deep recesses between them known as *fissures.* These fissures and convolutions serve as convenient points of reference in a description of the cortex. Also for purposes of reference the cortex is divided into *lobes.* Anterior to the *fissure of Rolando* is the *frontal lobe* (see Figure 65); posterior to the same fissure and above the *fissure of Sylvius* is the *parietal lobe;* at the extreme posterior portion is the *occipital lobe* and below the fissure of Sylvius, on the lateral surface of the cortex, is the *temporal lobe;* on the ventral surface, where the hemispheres fold under, is the *hippocampal lobe.*

The hippocampal lobe contains the so-called *area for smell* in its anterior section and the *area for taste* in the posterior section. The temporal lobe contains the *area for audition* and the occipital lobe contains the *visual area.* In the parietal lobe, just posterior to the fissure of Rolando, is the *body-sense* (*somaesthetic*) *area;* immediately anterior to the fissure of

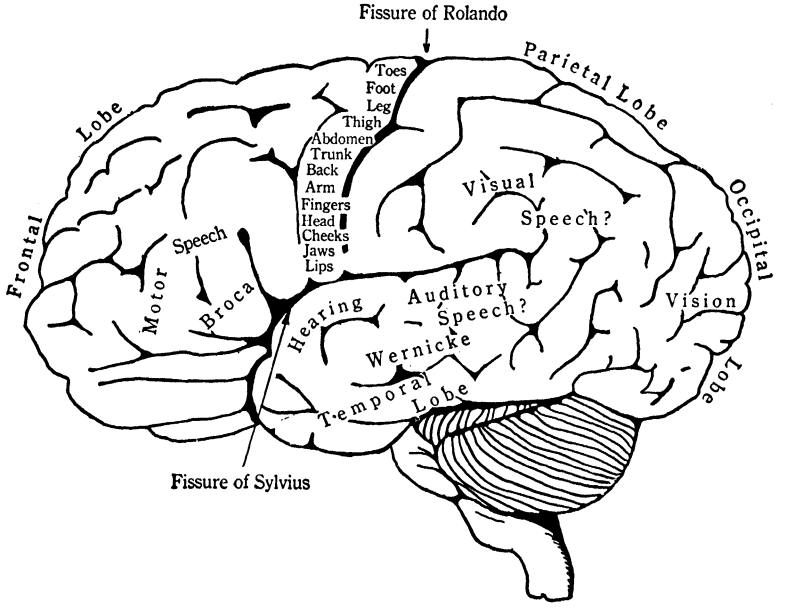


FIG. 65. LATERAL VIEW (left) OF HUMAN BRAIN.

This view shows the major convolutions and fissures of the human brain (left side) and the positions of the major lobes. The so-called 'areas' of the cortex are also indicated. The *Hippocampal lobe* is back of the *Temporal lobe* and would show if the under surface of the brain were exposed to view. The 'striped' organ is the cerebellum. Anterior to it (left) is the pons and beneath it is the medulla.

Rolando is the *motor area.* The remaining surface is supposedly given over to *association.*

We have seen how the visual and auditory areas connect with the eye and ear over devious routes. The body-sense area is reached by a chain of sensory neurons leading up the cord through the medulla and thalamus. The hippocampus is supplied by fibers from the olfactory region, leading through the olfactory bulbs and tracts. The routes of taste fibers

are not known, neither are the routes of the equilibratory fibers. From the motor area of the cortex, motor projection fibers lead downward without a break until they terminate at various levels of the cord, where they connect in the ventral horn with cells to the muscles. The upper section of the motor area subserves to a certain extent the muscles of the toes and feet and the lower part of the area connects with the muscles of the face and tongue. In other words, as we descend along the motor area we ascend on the body.

The Layers of the Cortex. The cerebral cortex is only two to four millimeters thick and yet it is composed of several layers. The outermost layer, .30 mm. in thickness, consists of nerve fibers; beneath it is one of the thickest of the layers, .83 mm. on the average, which contains large cell bodies called *pyramidal cells* (see page 499). These are the last to develop in the embryological growth of the nervous system; their dendrites are in the immediate vicinity and their axons go to various other parts of the cortex and to the spinal cord. In organic nervous diseases these cells are the first to deteriorate.

Below the layer of pyramidal cells is a middle cell layer .22 mm. thick. This layer is more highly developed in those regions of the cortex in which sensory fibers terminate, especially in the visual area. In blindness this region in the visual cortex degenerates; it is thought, therefore, to be receptor in function, handling the incoming impulses from the sense organs. Then comes an inner layer of fibers and another layer of cells (polymorphic cells). According to a questionable tradition these latter cells are supposed to control habitual and instinctive activities.

The Functions of the Nervous System

Size of the Brain as a Condition of Behavior. The evolution of the brain in mammals was characterized chiefly by a development of the telencephalon. Not only did the cortex increase in size, but the cortical neurons developed more branches and a greater number of long, connecting fibers. The increase in size of the cortex was made possible by an enlargement of the skull and by an increase in the number of

fissures and convolutions. Long fibers were especially important in the advance of nerve integration from simple to complex levels, for they not only brought remote parts of the organism into relationship with each other but placed them under the control of a central organ.

The size of the brain, however, is not alone a measure of intelligent behavior, as Table XIV shows.

TABLE XIV

COMPARISON OF BRAIN-WEIGHTS WITH BODY-WEIGHTS[1]

Animal	Brain-Weight	Body-weight
Squirrel	6	400
Cat	30	3,500
Monkey (macaque)	100	5,000
Dog (very large)	120	46,000
Sheep	130	50,000
Seal	300	26,000
Gorilla	400	90,000
Hippopotamus	580	1,750,000
Horse	600	300,000
Man	1,400	70,000
Elephant	5,000	2,500,000
Whale	7,000	70,000,000

TABLE XV

RATIO OF BRAIN TO BODY-WEIGHT

Animal	Ratio
Whale	1/10,000
Hippopotamus	1/3,000
Horse	1/500
Elephant	1/500
Dog (very large)	1/400
Sheep	1/400
Gorilla	1/250
Cat	1/110
Seal	1/90
Squirrel	1/80
Monkey (macaque)	1/50
Man	1/50

Not only does the size of the brain increase as we proceed along the animal scale, but it increases as body-weight in-

[1] From Warnecke, after Ladd and Woodworth, 34. Cf. Warnecke, *J. f. Psy. u. Neurol.*, 1908, Vol. 13, 355.

creases. We may interpret this latter fact to mean that the greater the number of muscle cells the more brain cells are needed to make muscle co-ordination possible. Likewise, the greater the surface of the body the more pain, pressure and other receptors there are, all of which must presumably be represented by cortical cells. Support for this view is found in the fact that in the whale and elephant the cortex is elaborately convoluted, thus giving it more bulk. Further evidence is derived from the fact that in certain of the huge prehistoric animals having especially large hind quarters there was a ganglion at the lower end of the spinal cord, larger than the brain. This ganglion was apparently necessary in accommodating the mass of musculature of the hind legs.

A glance at Table XV shows that while the whale has the largest brain of any of the animals, it is the smallest in proportion to the size of its body. Therefore, size of the body is obviously only one factor among the many that condition the size of the brain. The same table reveals the interesting fact that the brain in man is heavier in proportion to his body than in most of the other animals. This difference in proportion might be taken to measure the extent to which size of the brain conditions degree of intelligence in the species, but we are prevented from drawing such a conclusion by the fact that the monkey, seal and squirrel show approximately the same high ratio. *We may assume that the agility of the animal is correlated with the ratio of brain to body-weight. That is, the more agile the animal the more brain material is needed per unit of body-weight in order to make possible a great variety of delicate muscular co-ordinations. Not only is variety a factor demanding brain cells, but also speed and precision of movement.* All of these are found in the monkey, squirrel and seal.

In connection with the problem of the brain as a whole it is interesting to note that richness of convolution provides a physical basis for a greater variety and complication of energy-patterns, thus making possible a behavior that is not only complex but easily modified. In insects, for example, whose brains are of the solid, non-convoluted type, behavior is relatively stereotyped. The solid brain makes possible, physi-

cally, only a small number of different responses. The greater the surface area compared with the volume of the brain, the more numerous and diversified the patterns of energy that can be formed within.

In man there is a wide range of brain weights and very little correlation between size of the brain and degree of intelligence until we compare imbeciles of certain classes with normal individuals (see page 113). One of the heaviest known human brains came from a feebleminded individual, and certain intellectual genuises have had exceptionally small brains. The average brain-weight for human males is 1400 grams; Thackeray possessed a brain weighing 1658 grams; Daniel Webster's brain weighed 1518 grams; Liebig, a famous chemist, possessed a brain of only 1352 grams; the brain of Anatole France was exceptionally light, 1017 grams. The brain-weight of human beings varies with age, even after maturity is reached, for brains become lighter as their water content decreases. Brains vary also with the weight and height of the individual; in general the taller the person the larger the brain. Here again evidence supports the view that the bulk of the body is associated with size of the brain.

The Brain Patterns of Primates Contrasted with Pre-Primates. The evolution of intelligent behavior is correlated with the growth of a particular type of brain pattern. If the brains of the pre-primates are examined it will be noted that in each instance there is only a very small frontal lobe. The fissure that corresponds to Sylvius lies very close to the anterior pole (see Figure 66). Even in the most complex of all pre-primate brains, those of the horse, elephant and whale, this fissure is still far forward. The fissure of Rolando has migrated back toward the central region, but not far, and it is still a minor fissure. *Once the direct ancestral line of the human being is reached, however, the cerebral pattern shows a marked change.* The frontal lobe begins suddenly to develop. In its evolution three striking events take place. First, the frontal lobe enlarges and submerges the area that shows on the lateral exterior of the pre-primate brain. This area, in the human brain, becomes the Island of Reil, beneath the deep fold of the fissure of Sylvius. Second, with the enlargement

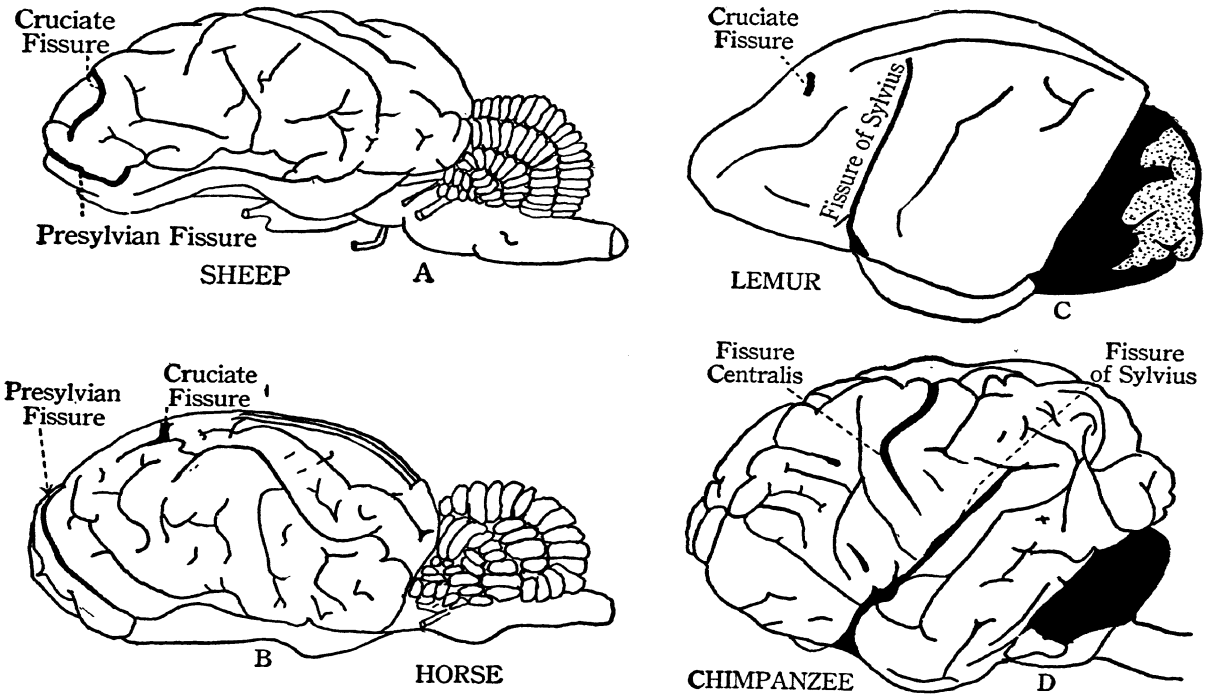


FIG. 66. CONTRAST BETWEEN PRE-PRIMATE AND PRIMATE BRAIN PATTERNS.

Diagrams *C* and *D* modified after Tilney, *The Brain from Ape to Man*, Hoeber, 1928. The *Cruciate fissure* is the genetic antecedent of the Fissure of Rolando. The *Presylvian fissure* is the genetic antecedent of the Fissure of Sylvius. *Fissure centralis* is another name for the Fissure of Rolando. (The names of these aspects of the nervous system, along with many others, are now undergoing a systematic revision.)

of the frontal lobe both the fissures of Sylvius and Rolando deepen and migrate backward. Third, the occipital lobe increases in size and covers a large portion of the cerebellum. Finally, all over the cortex, convolutions and fissures become numerous, giving more space to gray matter. These progressive changes may be observed, starting with the lemur, the most primitive form of the primate line, and passing up through the lower monkeys to the ape, the gorilla having the most highly developed of anthropoid brains below man.[2]

There is some evidence that the frontal lobe plays an important part in controlling the activities of the lower and more primitive centers of the brain and in stabilizing the general behavior of the organism. It may be conjectured that the development of the primate brain, especially of the frontal lobes, 'anticipated' the complicated control of the rest of the nervous system that is so important in human behavior where intricate social relations are involved. We are reminded of the fashion in which the undeveloped nervous system of the embryo 'anticipates' in its early stages of growth the control which it later exerts over its specialized centers whose development follows later (see page 492). Brain pattern, then, correlates better with intelligence than do the size and richness of convolution.

SUMMARY OF FUNCTIONS OF LOWER BRAIN CENTERS.

Spinal cord:

- Transmits to brain from sensory neurons.
- Transmits from brain to muscles.
- Connects different levels of the body.
- Connects one side of the body with the other.
- Originally the organ of such conscious behavior as took place in the higher invertebrates and lower vertebrates.

Medulla:

- Co-ordinating center of tongue movements in eating and speaking.
- Co-ordinating center of throat muscles in speech.
- Co-ordinating centers of compensatory reflexes.
- Co-ordinating center of the vagus nerve, controlling breathing

[2] See Tilney, F., *The Brain from Ape to Man.* New York: Hoeber, 1928.

and heart action, digestive secretions and movements of the alimentary tract. Integrates stomach and salivary glands with sight and hearing.
Connects the head and body with the cerebellum.
Controls secretions of mucous membranes of the head.
Contains centers for co-ordination of muscles in deglutition, coughing, hiccoughing, vomiting, etc.
Conducts to the cord from midbrain and thalamus.
Conducts motor impulses passing down from cortex to pyramidal tracts of the cord.
Receives from the cerebellum and relays to the cord and cortex.
Transmits all manner of local impulses.

The pons:

Aids in prehension and mastication of food.
Aids in control of facial expression.
Controls lateral movements of the eyes.
Receives and integrates equilibratory impulses from semicircular canals.
Receives and integrates impulses from the ear.
Aids in control of throat co-ordinations in speech.
Contains center for conjectival, gum, lip and pinna reflexes.
Connects cortex with the cerebellum.
Relays to cerebellum from numerous sources above and below.
Connects midbrain with the cord.

The cerebellum:

Supports tonus of skeletal musculature.
Maintains balance and bodily attitudes.
Receives from organ of equilibrium.
Receives from practically all parts of the nervous system and sends to practically all parts.
An adjunct to the motor functions of the brain.

Corpora quadrigemina and adjacent regions:

Controls many eye-motor co-ordinations.
Contains primitive visual and auditory centers.
Connects cerebellum with many other regions of the nervous system.
Relays visual and auditory impulses to the cortex.
Concerned with numerous eye and ear connections with the cortex and the cord.

Thalamus:

Contains about 20 nuclei, relaying visual, auditory, tactual, kinaesthetic, pain and temperature impulses to the cerebral cortex.
Also contains motor centers having to do with emotive behavior.
Connects with the hippocampus.

The Problem of Localization of Function in the Cortex. Localization of function is one of the outstanding problems

of the relationship between the nervous system and behavior. Do certain parts of the brain, especially certain areas of the cortex, exert exclusive control over specific modes of response? For example, is there a particular area in the brain that is alone responsible for vision, another for hearing, another for muscular co-ordination of the fingers and hands and another for co-ordination of the legs? An affirmative answer to these questions has been commonly given on the basis of certain facts which we shall presently discuss.

History of the Problem of Localization: Ancient Beliefs. The history of the problem commences with Hippocrates, a Greek physician, living 460–377 B.C., one of the very few Ancients who conceived of any association between the brain and conscious behavior. We have already seen how Aristotle located certain emotions in the heart and others in the abdomen; he also thought that the brain and nerves were a heating system for the body. Later a famous physician, Galen, A.D. 131–203, located imagination in the frontal lobe of the brain, intelligence in the center and memory in the posterior section. This was one of the first systematic attempts to explain different types of behavior in terms of specific regions of the brain. We have already mentioned, also, the efforts of Gall in 1810 and of Spurzheim in 1832 to create a science of phrenology by means of which the development of traits of character could be predicted by measurements of the skull, the assumption being that the contour of the skull indicated development or lack of development of the brain material beneath. This theory was attacked vigorously in 1822 to 1824 by Flourens, who extirpated different parts of brains in animals and noted the effect on their behavior. Various striking effects occurred; injury to the cerebellum seriously interfered with the tonus of the animal's muscles and with its muscular co-ordination; destruction of certain regions of the cortex paralyzed the animal, but destruction of other parts seemed to have very little effect on its behavior.

Motor Areas. In 1861, Broca[3] published a famous work on aphasia. Aphasia is inability to speak, or to under-

[3] *Bull. de la Soc. Anatomique,* Paris, 1861–1863.

stand language. He found that in many cases of motor aphasia or inability to control the speech muscles, there was a lesion on the left side of the cortex, anterior to the lower end of the fissure of Rolando in right handed people and on the right side in left handed people. This was known as Broca's area, or the area for speech.

In 1864, Hughlings Jackson introduced the notion of reflex levels, implying stages of complexity of reflex co-ordination. The spinal cord was the first and lowest level, which was supposed to accommodate reflex integration of the bodily receptors with the muscles of the body below the neck. The medulla and midbrain composed a region that controlled reflexes of the second level, that is to say, integrations between the senses of the head and muscles of the head and body. Here might be included the automatic orientation of the body to gravity, turning the eyes and head toward an object seen in peripheral vision, turning toward a sound and the like. The cerebral cortex was the integrating center for reflexes of the third level, or 'conscious reflexes,' which include voluntary and intelligent behavior.

An important step in the history of the problem was made, in 1870, by Fritsch and Hitzig [4] who stimulated various parts of the cerebral cortex in dogs with an electric current, establishing localization of function within the motor area. In 1873,[5] this work was verified and extended by Ferrier; in 1892, Sherrington found that the cerebral cortex, especially the frontal areas, exhibited an inhibiting effect over lower brain centers. In 1903 [6] the same investigator explored the motor cortex of monkeys by the electrical method. As a result of these studies it seemed firmly established that, anterior to the fissure of Rolando, there was an area which controlled the voluntary motor co-ordinations of the body.

Sensory Areas. Meanwhile [7] evidence also accumulated in favor of specific *sensory areas.* The area posterior to the fissure of Rolando was established as a body-sense area

[4] *Archiv. f. Anat. und Physiol.,* 1870, 300 f.
[5] Cf. Ferrier, *Functions of the Brain,* London, 1876.
[6] *Proc. Royal Soc.,* London, Vol. 72, 1903, 152.
[7] Cf. Luciani's *Human Physiology,* Vol. III, New York, 1915 (Tr. Welby).

by the work of Luciani, 1885, von Monakov, 1902, Flechsig, 1904, Campbell, 1905, and Cushing in 1909. Panizza had noticed as early as 1855 that a dog could not see after an injury to the occipital lobe. In 1875, Ferrier elicited eye-movements when he electrically stimulated the cuneus in certain animals. In 1878, Munk noticed that blindness in human beings was associated with lesions and tumors of the cuneus. From 1888 to 1890 Brown, Schafer and others found that there was localization of function within the cuneus (see page 455). In 1905 Panichi, working on animals, noticed that destruction of the visual area did not render the subject permanently blind, but that if the whole occipital lobe was ablated, blindness was apparently permanent.

In 1875, Ferrier noticed that electrical stimulation of a region in the temporal lobe produced ear-movements in the dog. From 1878 to 1881 Munk studied deafness in cases of lesions of this area in human beings. Bechterew found, in 1887, that the boundaries of the auditory area varied to a considerable extent in different animals of the same species. In 1874, Wernicke noted the importance of the auditory area in cases of sensory aphasia, an aphasia in which the patient is unable to understand spoken language. In 1905, Wilson located the taste area in the posterior region of the hippocampus. Ferrier had much earlier found the smell area in the anterior portion of the same lobe.

Function of the Cortex as a Whole. But what about the functioning of the cortex as a whole? Evidently as evolution took place in the animal scale the cerebral cortex became increasingly more important; the functioning of the lower centers was either taken over or subjected to control by the higher centers. Indications of this fact came *first* from Bandolet's work in 1864. Bandolet removed the cerebral hemispheres in fishes and produced an artificial sluggishness in their behavior; they could move normally, however, when forced. They apparently retained their sight until the midbrain was removed; removal of the midbrain also destroyed equilibrium. We have noted that the midbrain contains a primitive integrating center for vision and that human beings and the higher animals are made blind, at least temporarily,

by destruction of the cortical visual area. We have also seen that destruction of the motor area produces paralysis in the higher animals. It would appear that both in the case of movement and of seeing, destruction of the more highly evolved and specialized brains of higher animals produces a proportionately greater effect upon behavior. *Second,* Goltz and Blanschko[8] furnished evidence for these conclusions when they removed the cerebral hemispheres in frogs and found relatively few modifications in their behavior. For example, the frogs jumped, swam normally and righted themselves when placed on their backs, although their normal attitude with the cortex removed was passive; they took no food, and would not croak except when stimulated by pressure on the chest or abdomen. If the thalamus was not destroyed they could still see and could avoid objects when forced to move. With only the mid and hind-brain intact, the animal would not attempt to save itself when immersed in a pan of water slowly heated to boiling.

A *third* line of evidence was produced in 1890 by Bechterew[9] who removed the cerebral hemispheres from birds. Decerebrated, they assumed one position and remained there, making ceaseless head movements; but if thrown into the air, they would fly. They could see, but they could not see intelligently for they would light on any object, no matter how dangerous. They would not eat of their own initiative and showed no interest in other birds, even of the same species. In 1892, Goltz[10] reported similar experiments on dogs. The dogs showed no initiative other than a general restlessness. They would not eat at first, but finally responded when food was held directly under their noses. They showed no signs of 'memory' and 'recognition.'

In 1913, Edinger and Fischer[11] reported the case of a human infant who lacked a cerebral cortex. It revealed no sign of intelligent behavior, and no signs of hunger, thirst,

[8] Goltz, *Beiträge zur Lehre von den Functionen der Nervenzentren der Frosches.* Berlin, 1869. Cf. Luciani, *op. cit.,* Vol. III, 497 f.

[9] Cf. Schäfer's *Physiology,* Vol. II, 98 ff.

[10] "Das Hund ohne Grosshirn," *Arch. f. d. ges. Physiol.,* 1892, Vol. 51, 570–615.

[11] "Eine Mensch ohne Grosshirn," *Arch. f. d. ges. Physiol.,* Vol. 152, 1913, 1–27.

or other sensory processes, but sucked when put to the breast; and as it grew older, it cried continuously. Until it was a year old it made no spontaneous movements of the limbs. Not long thereafter it died.

Fourth, the frontal lobes are the last to develop in the life history of the individual. Indeed, it is probable that they do not function fully until during or after adolescence; then they play an important rôle in the inhibition of impulsive behavior. The case is reported of a young boy who was kicked in the forehead by a horse; pieces of bone mashed the anterior portion of each frontal lobe, making it necessary in cleaning the wound to remove several spoonfuls of brain matter. The boy recovered and showed no disturbance of behavior until he reached the adolescent period, when he became impulsive, erratic and unmanageable. Other cases also indicate that the frontal lobe is important in maintaining normal inhibitions and a stable personality.[12]

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[12] Tilney and Riley, *The Form and Functions of the Central Nervous System.* New York: Hoeber, 1923, 2d ed., 905 ff.

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CHAPTER XVII

THE NERVOUS SYSTEM IN ITS RELATION TO BEHAVIOR

Present Status of the Problem of Localization of Function

Evidence from Pathology. From studies of abnormal behavior, caused by lesions, tumors and other organic disturbances, it appears that the human being makes two general types of movements: First, so-called 'voluntary' movements the goals for which are consciously set up by the individual. These movements are under the control both of the cerebral cortex and of various masses of nuclei beneath the cortex (caudate nucleus, lenticular nucleus, thalamus). Precisely what contribution the cortex makes other than in relating the movements to a consciously perceived goal is not known except that it gives them more vigor than they would otherwise possess and acts as an inhibitor of the lower centers. When the control of the cortex over the lower centers is cut off by lesions, a second type of movement is still preserved, known as 'automatic associated movement.' The exact limits of this type are not known, but at least they include the rhythmic swinging of the arms and legs in walking, co-ordinating the head with the body in walking, turning, stooping and simultaneously co-ordinating the muscles on both sides of the face in 'expressing emotion.' Without cortical control these movements are likely to be erratic and ungoverned, and they occur quite normally when the individual is under emotional stress. For example, a patient suffering from a tumor of the frontal lobe is unable voluntarily to contract his fist but when he becomes angry he is able to make this movement perfectly. Cases are reported in which voluntary control of the facial

muscles is lost; nevertheless, when confronted by an emotional situation the patient can move the same muscles with practically normal co-ordination. Indeed, it has been said that fairly extensive paralyses and tremors occur where the patient is unable under ordinary circumstances to execute well co-ordinated arm and leg movements; yet, when he is faced suddenly by a crisis, like finding himself sinking in deep water, he is able to swim with perfect ease.

Tilney and Riley [1] trace the origin of automatic associated movements to the lower vertebrates in which the highest cerebral development was represented by the caudate and lenticular nuclei. When the cerebral cortex developed, superimposed upon these nuclei, the latter came under the dominance of the former but retained many of their old functions. In man the two types of movement are from outward appearances very much alike, but they differ markedly in the configurations in which they function and in the goals with respect to which they are co-ordinated. Hence the situation which confronts the individual in part conditions his responses, and activities which he is unable to carry out under one set of circumstances, he is at another time able to perform. These facts must be considered in facing the problem of cerebral localization of function, and also suggest the conclusion that the lower centers are more specific in their functions than the higher centers.

Turning to other lines of evidence, organic paralyses of the more delicate organs, like the speech muscles, occasioned by lesions in the speech area of the cortex, frequently resist all efforts at re-education. But under such circumstances, success has been achieved in training the patient to talk. Recovery is slow and the method of learning is difficult because the paralysis of the muscles results in eliminating the feeling of muscular contraction which is so important in the voluntary control of movement. The patient is able, however, to sub-

[1] Tilney, F., and Riley, H. A., *The Form and Functions of the Central Nervous System*, 2d ed., 1923. New York: Paul B. Hoeber. See also Tilney, F., and Morrison, J. F., "Pseudo-bulbar Palsy Clinically and Pathologically Considered," *J. Nerv. and Ment. Diseases*, 1912, Vol. 39, 505; and Wilson, S. A. K., "The Old Motor System and the New," *Arch. of Neur. and Psychiat.*, 1924, Vol. II, 385–404.

stitute cutaneous for kinaesthetic cues by feeling another person's throat with the tips of his fingers while the latter is speaking.

Patients recover gradually from paralytic strokes, although it is not known in every instance whether this regain of function follows the absorption of blood clots that have temporarily shut off certain nerve patterns without permanently injuring them, or whether the patterns were destroyed and others gradually assumed their function. Again, there are strokes from which the patient never recovers. The facts from the pathology of the human nervous system are often ambiguous, therefore, as to their interpretation. Nevertheless, one clear case of a return of function would suffice to cast doubt upon the theory of specific localization in the cortex and would point to the possibility that if the conditions were under control the patient would recover from injuries of considerable magnitude. It would lead also to the view that the loss of function is caused by destruction of an entire system of stresses involving the cortex as a whole, just as a chain no longer functions when a single link is broken. The recovery is slow because a great variety of new relationships must be established between uninjured parts of the nervous system and against the resistance offered by pre-existing patterns of stresses.

Present Status of the Localization Problem: Lashley's Experiments. In 1917, Lashley and Franz [2] reported on the persistence of habit and on relearning in the white rat, after various parts of the frontal, temporal and parietal lobes had been destroyed. Simple habits like turning in an easy maze continued after complete destruction of the frontal areas, but the more complex habit of opening the door of a food box by tilting an inclined plane could not be learned unless the frontal lobes were partially intact. Further experiments showed that a simple habit may be retained after the destruction of any given third of the cortex.

In 1920, Lashley [3] performed more extended experiments

[2] Lashley and Franz, "The Effects of Cerebral Destruction Upon Habit-formation and Retention in the Albino Rat." *Psychobiol.*, Vol. 1, 1917, 71–139.

[3] Lashley, K. S., "Studies of Cerebral Function in Learning." *Psychobiol.*, 1920, Vol. 2, 55–135.

on rats, from which he concluded that approximately one-half of the cortex, variously distributed, could be destroyed without affecting the formation of simple habits. It made no difference apparently where these lesions happened to be. In 1921, he [4] first trained his rats to choose an illuminated alley rather than a darkened alley from which to secure food. After learning was complete he gave them an additional practice of twelve hundred repetitions; then he destroyed different areas, including the visual. The habit disappeared only when the visual area was destroyed. This experiment seemed to demonstrate, first, that the visual was apparently the only cortical area involved in the learning; second, that the over-learned habit was not transferred to sub-cortical levels, and third, that destroying the visual area did not permanently eliminate the habits. Later, he [5] destroyed the visual areas in a number of animals. After the operation he trained them in discrimination of brightness, and by a second operation explored the remaining parts of the cortex in an effort to discover what part of the cerebrum had assumed the visual function. That is, by destroying different regions in different rats he expected to find the area that took over the lost visual function, for presumably the rat in which that particular area was destroyed would lose the habit again. But the experiment showed that no particular area seemed to be the necessary one! Only when a certain maximum of tissue was destroyed was the habit lost and it made little or no difference where the lesions were.

Another study by the same author [6] showed that visual and motor habits did not ultimately depend upon the motor areas of the frontal lobe. The performance of one particular rat in this experiment is noteworthy; the rat was a small female, 90 days old, trained to select food from the brighter of two alleys. Ninety trials were required in the original learning, prior to the operation; then the frontal lobes were transected

[4] Lashley, K. S., "Studies of Cerebral Function in Learning II. The Effects of Long Continued Practice upon Cerebral Localization," *J. of Comp. Psy.*, Vol. 1, 1921, 453–468.

[5] Lashley, K. S., "Studies of Cerebral Function in Learning IV. Vicarious Function after Destruction of the Visual Areas." *Amer. J. Physiol.*, Vol. 59, 1922, 44–71.

[6] Lashley, K. S., "Studies of Cerebral Function in Learning III. The Motor Areas." *Brain*, Vol. 44, 1921, 255–285.

and the caudate nuclei (large motor nuclei beneath the cortex) were destroyed by cauterization. During the first week after the operation the animal was unable to walk except in six-inch circles and could not make her way through the discrimination box. Nine days after the operation the disturbance had cleared sufficiently to allow walking in a straight line but when she attempted to change her direction she was obliged to rotate.

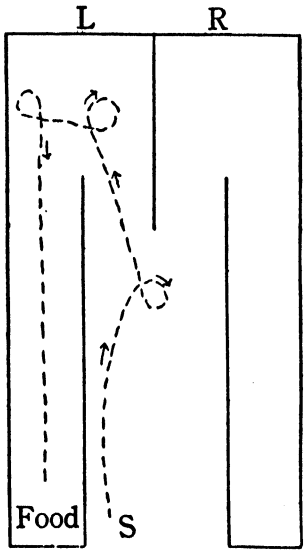


FIG. 67. PATH OF LASHLEY'S RAT.

About this time she was given tests in the discrimination box in order to discover if the habit had persisted. She was still unable to turn to the left, *but whenever her position in the box required a 90-degree turn to the left she rotated 270 degrees to the right in order to reach the goal.* A glance at Figure 67 shows one of her simpler routes; notice that to reach the food she rotated to the right three times. We shall refer to this fact in our discussion of reflex action.

In 1923 and 1924 Lashley[7] extended his investigations to the Cebus monkey. In these experiments he found that destruction of the motor area did not permanently affect the learning process. It was evident, therefore, that the motor area was not the exclusive 'seat' of 'voluntary movements.' The first effect of the operation was a paralysis, but after recovery the learned movements took place with equally as good coordination as before, only with less force and with greater susceptibility to fatigue. Evidently after the operation the animal lacked *a sufficient mass of nerve impulses to maintain normal muscular activity.* In other words, for normal be-

[7] Lashley, K. S., V. "The retention of motor habits after destruction of the so-called motor areas in Primates," *Arch. Neur. and Psychiat.*, Vol. 14, 1924, 249–276.
Lashley, K. S., VI. "The theory that synaptic resistance is reduced by the passage of the nerve impulse," *Psy. Rev.*, Vol. 31, 1924, 369–376.

havior there is required a cortical facilitation of movements whose direction and complexity are controlled not by the *motor cortex* but by other parts of the brain. This facilitation comes from the so-called motor area. Before discussing the significance of these facts for a physiological theory of behavior it will be necessary to consider what views have been entertained regarding the functioning of the neuron, and the reflex arc.

Cameron's Experiments.[8] Suspecting that Lashley's results on rats were in part dependent upon the fact that the animals were trained in problems that were too simple, Cameron performed a series of experiments with rats whose frontal lobes had been destroyed; but he used more difficult mazes. While the operated rats showed retention of old habits and were able to learn new problems in the maze, their performances were inferior to those of normal rats. The types of errors made by the operated rats, indeed the entire behavior of these animals, indicated that they were less able than the normal rats to meet *the problem situation as a whole.* As a consequence Cameron suggests that the effect of the operation was that of 'disequilibrating' a complex dynamic system, or in other words, of disturbing the functioning of the cerebral cortex as a whole. As far as they bear upon the problem of localization, therefore, his results and interpretations are practically in accord with Lashley's.

The Neuron Theory. Theories of the functioning of the nervous system evolved from purely anatomical considerations. If the nervous system is composed of neurons why is not its functioning to be explained in terms of neurons? In other words, why is not the whole to be explained by its parts? That this was the assumption is indicated by the following six propositions which were for a long time accepted as facts:

1. The neuron of the adult animal is an anatomical unit; it corresponds morphologically to one cell. 2. The neuron is a genetic unit, for it is differentiated from a single type embryonic cell. 3. Within the nervous system there are no ele-

[8] Cameron, Norman, "Cerebral Destruction in Its Relation to Maze Learning." *Psy. Mon.*, 1928, Vol. 39 (No. 177), 1–68.

ments other than neurons which participate in nervous functions. 4. The neurons remain anatomically separate at the synapse; they are merely in contact with each other, that is, there are no connections between them which can be characterized as conditions or continuity or fusion of their substance. 5. The neuron is a trophic unit; this means that the injury of any part of the neuron affects the welfare of the whole, and the destruction of the nucleus and cell body lead to degeneration of the entire neuron, but such injuries do not directly affect adjacent neurons. 6. The neuron is the functional unit of the nervous system.

Recent work casts considerable doubt upon a number of these propositions. While there seem to be no reasons for modifying 1, 2 and 5, 3 is evidently too arbitrary. The original protoplasm from which nerve tissue differentiated possesses to some extent the properties of nerve cells, namely, irritability and conductivity. It is not certain that the protoplasm surrounding the nerve cells, especially in gray matter, plays no part in the conduction process. Four has been attacked by certain neurologists who claim to have demonstrated continuity between neurons. The balance of opinion, however, favors the concept of the synapse as a distinct gap in the conducting substance produced by membranes both at the end of one cell and at the beginning of the other. Proposition number 6 is certainly to be doubted; the neuron is a functional unit only in a very limited sense of the term, for how a single neuron will function depends upon activities in surrounding neurons and, indeed, upon the state of excitability of the entire section of the nervous system in which the neuron is found.

Polarization of the Neuron. Neurons are *polarized* when functioning in chains, that is, a chain conducts only in one direction from the axon of one neuron to the dendrite and cell body of another. The work of Coghill [9] indicates how the neuron acquires its polarity. As suggested by his studies on the embryo of the water lizard (*Amblystoma*) embryonic tissue (mesoderm) that develops into muscle exhibits a metabolic gradient with its highest rate at the tail end of the animal and

[9] Coghill, G. E., *Anatomy and the Problem of Behavior.* New York: Macmillan, 1929.

its lowest rate at the head end. Tissue (ectoderm) that develops into nerve material exhibits a gradient with its highest rate at the head end and its lowest rate at the tail end. The cell bodies of the nervous system develop in the embryonic spinal cord and brain and send out fibers in two directions. Those fibers which extend into regions of a higher rate of metabolic activity become axons and those which grow into regions of a lower rate become dendrites. Hence the polarity of neurons. In other words, the end that shall receive impulses and the end that shall discharge them are determined by metabolic gradients *before the neurons develop.* The synapse, then, is evidently not the factor that conditions the polarity of the neuron.

The Synapse Theory of Nerve Integration. The fact that the neuron is polarized when it functions in chains has implicated the problem of the resistance at the synapse. Now it is obvious that conduction requires time; moreover, the transmission of an impulse along a fiber is faster than the transmission through a synapse. This fact led to the belief at one time that there was an obstruction or a resistance at the synapse which did not occur elsewhere in the chain of neurons, a view that was thought to be of utmost physiological importance. If the synapse offers resistance to the passage of an impulse the degree of resistance might vary under different conditions, in which case we have a clue to an explanation of nerve integration, for nerve impulses would travel through those particular synapses which offer the least resistance. Accordingly, there evolved a popular explanation of habit formation and the belief that the laws of exercise, frequency and recency had been vindicated. The more a particular synapse is used, it was said, the less resistance it offers to the passage of nerve impulses. Furthermore, resistance at the synapse was supposed to be lowered more rapidly when the act ended in pleasure; when the act ended in displeasure resistance at the synapse was increased! However, the synaptic theory of habit formation still awaits facts from the physiological laboratory, although there are many available working hypotheses. (1) The synapse restrains diffusion of nerve impulses and thus directs them along certain channels from one

part of the nervous system to another; (2) the synapse banks up osmotic pressure; (3) it restricts movements of ions; (4) it accumulates electrical charges; (5) it suffers an alteration in shape and in surface tension when changes in potential occur on either side; (6) it acts as an intervening membrane between dilute solutions of electrolytes or between different concentrations of collodial suspension with different signs of charge.[10] But none of these theories enables us to understand how the mere passage of an impulse through the synapse would permanently change the synapse any more than an electric current passing over a wire would permanently change the wire, nor do they explain how pleasure and displeasure could affect events at the synapse.

Efforts to Explain the Law of Effect Physiologically. The law of effect claimed to rest upon the circumstances that pleasure is experienced when a nerve unit actually conducts on being ready to conduct, and second, that unpleasantness arises when it does not conduct; conversely, annoyance results if a neuron is forced to conduct when it is not ready. But the evidence is derived from superficial observations on the annoying character of certain performances in fatigue and neurasthenia when the same performances are pleasant under conditions of excellent health. The difficulties with an attempt to relate pleasantness and unpleasantness to readiness and lack of readiness to conduct should be obvious. First, readiness and unreadiness to conduct can hardly be called properties of conduction systems. A wire that offers resistance to a current is neither ready nor unready to conduct; it makes no difference to the wire; it makes no difference to the neuron. Moreover, if unreadiness were a fact it would not produce displeasure, and readiness would not produce pleasure; a neuron conducts as its composition at the time permits, and it is as easy for it to conduct at one time as at another, regardless of the amount it conducts (cf. all-or-none principle, page 494). On the other hand, *it does make a difference to the organism-as-a-whole what goals it happens to be seeking, and if there is a conflict between goals displeasure arises.* What causes the

[10] Herrick, C. J., *Introduction to Neurology.* Philadelphia: Saunders and Company, 1927, 4th ed.

displeasure is practically certain; it is intra-organic tension, the experience of which depends not upon readiness and unreadiness of conduction systems, but upon the functioning of body receptors. Likewise, that pleasantness is peripherally aroused is also practically certain.

Concept of the Reflex Arc. In the course of time the neuron and synapse theories were combined into a *reflex arc theory.* In its simplest terms a reflex arc, in human beings, is by definition composed, (1) of a receptor and (2) of a sensory neuron leading into the spinal cord where it makes synaptic connections with (3) a motor neuron that leads back to a muscle. Next in complexity is the interposition of an association neuron between the sensory and motor neuron, in which case the latter may lead to a muscle on the opposite side of the body. There is no end to the possible complication of reflex arcs. In fact the conductor system between receptors and contractile or secretive tissue anywhere in the body has been regarded as a reflex arc.

The Concept of Reflex Action. The actual neural mechanisms responsible for the simplest kind of muscular movement are enormously complex, involving the simultaneous functioning of thousands of neurons. Regardless of its complexity, a reflex act is defined as a stereotyped contraction of a group of muscles (or a secretion of a certain gland) as a result first, of a given stimulus, and second, (supposedly) of an inherited arrangement of conduction paths. Hence reflex is by definition practically *unmodifiable;* given the same stimulus repeatedly, the same end product will always occur.

Such activities as these are few in number in human behavior; in fact there is practically no agreement concerning the human activities that should be classified as reflexes. The following are often listed, certain of which are subject to voluntary control:

1. Pupillary or iris reflex
2. Digestive reflexes
3. Shivering
4. Trembling.
5. Winking.
6. Accommodation

7. Hiccoughing
8. Patellar reflex (knee jerk)
9. Vomiting
10. Salivation
11. Sudorific reflexes (sweating)
12. Sneezing
13. Postural reflexes

Many writers would add reactions like the following:

14. Shuddering
15. Starting to a sudden noise (frightened)
16. Withdrawing the hand from heat and pain stimuli
17. Yawning
18. Tickle reflexes
19. Stretching
20. Wincing

These latter seem too nearly of a voluntary character, and too variable, to be called reflexes. The author would confine the term reflex action to those stereotyped responses of the intact organism that are under the control of the *autonomic nervous system.* Hence the vegetative functions of the body and a few reactions like coughing and hiccoughing, caused by stimulation of internal organs, would be called reflexes.

Sherrington's Work on Co-ordination in the Simple Reflex. True reflex action is best studied in animals. Since under normal conditions they have only a limited number of stereotyped reflexes it is necessary to reduce the organism-as-a-whole to a simpler state, devoid of initiative and of goal activity. This is accomplished by separating the brain from the spinal cord. The animal will then live for several days and even weeks if properly cared for. Such an animal is called a spinal animal, or decerebrate preparation, since its activities of whatever character are largely under the control of the spinal cord. The spinal animal exhibits various typical reflexes, for example, an extensor thrust of the leg (dog) elicited by pressing between the plantar cushion and the toe pads, with the animal's hip and knee resting passively flexed. Another is a flexion reflex, or withdrawal of the leg, when the bottom of the foot is pricked; another is a scratch reflex, a

typical pumping motion of the leg when the side of the body is tickled.

Research work by Sherrington [11] and others on reactions of this type has led to a wealth of facts, a selected number of which are presented here. (1) Conduction over the reflex arc exhibits an *after-discharge* or continued contraction of the muscles after the stimulus has been removed; in certain reflexes this is as brief as $\frac{1}{10}$ (perhaps $\frac{1}{100}$th) of a second, and in others it lasts for five seconds or more. (2) The reflex arc exhibits a *refractory period;* that is, immediately after it has responded once, a certain interval of time elapses before it will respond again. This refractory period is of great importance in permitting a muscle to relax before it is forced to contract again. Especially obvious is its importance for rhythmic action such as the heart beat and breathing. (3) The reflex arc shows the effect of *summation of stimuli.* Let a very light stimulus be applied to the sole of the hind foot in a decerebrate dog and there will be no withdrawal of the leg; repeat the stimulation without increasing its intensity and there may be no response. But after a sufficient number of stimulations the leg will contract; the effect of the stimulation is accumulative. Summation is illustrated on a higher level of action, in the ease with which a person feels the crawling of an insect across the skin, but feels nothing until the insect moves. A sleeper will not awaken until his name is called the third or fourth time. (4) Reflex action exhibits the phenomenon of *irradiation* (see page 294). (5) In the simple reflex arc, rhythm of muscular contraction does not always correspond to rhythm of stimulation, a fact to be explained by the *refractory period.* (6) The intensity of the motor response does not correspond to the intensity of the stimulus. The response represents an amount of force disproportionate to the energy of the stimulus. This is because the neuromuscular system contains 'stored energy.' (7) The reflex arc exhibits a *latent time,* a period between the presentation of the stimulus and the appearance of the response; it is the reaction time of the reflex arc. In the simpler reflexes it may be about fifty

[11] Sherrington, C. S., *Integrative Action of the Nervous System.* Yale Univ. Press, 1906.

sigma; in the more complex reflexes it is frequently as long as two and three seconds. (8) The same stimulus may excite one group of muscles and *simultaneously* inhibit the contraction of antagonistic muscles, or, the same stimulus may excite one group of muscles and *successively* inhibit action of the opposing muscles. This latter is known as *reciprocal inhibition* and is of vital importance in the co-ordination of opposed sets of muscles. What would happen if at the same time a stimulus was producing flexion of the leg, another stimulus succeeded in setting off an extensor thrust? The result would be a contraction of two opposed sets of muscles, with no movement. (9) One stimulus may reinforce the effect of another when the resulting responses *are for the same or a similar purpose.* Two reflexes which thus facilitate each other are said to be *allied.* For example, if a person was walking along the street and a dog barked at his heels suddenly, he would jump, but if someone slapped him on the shoulder at the same time the dog barked, he would probably jump much farther. In this case an auditory and a cutaneous 'reflex' are mutually reinforced. (10) Reflexes having *different effects* interfere with each other and are called *antagonistic.* This interference is reversible between the two reflexes. To give an example from a higher level of action, one can not study well when a tooth aches. (11) Other things being equal, reflexes to pain and unpleasant stimuli preempt the use of the organism's muscles. These are *pre-potent* and will inhibit the simultaneous appearance of other reflexes. Various reflexes are elicited by different stimuli, but all demand the use of the same set of muscles and the same set of motor neurons. In other words the motor mechanism is used in common by a diversity of sensory avenues; there is a *final common path* of discharge of energy from the central nervous system. The principle of the final common path is said to explain 'attention,' attention being the response which at any given moment dominates the final common path. *Insofar as results from such studies as these are applicable to the behavior of the organism-as-a-whole they are independent of the concept of reflex action. They depend upon general properties of the nervous system.*

THE REFLEX *vs.* THE ORGANISMIC BASIS OF BEHAVIOR

Inadequacy of the Concept of Reflex Action in Accounting for Behavior. (1) Logical Difficulties with the Reflex Arc Concept. The reflex arc proved to be a very popular, but an unsafe explanatory principle, as John Dewey pointed out as early as 1893.[12]

First of all the reflex arc was conceived as a tri-partite affair made up of a sensory, an association and a motor neuron. 'Consciousness' depended only upon the sensory side of the reflex arc; movement was dependent upon the motor side; integration depended upon association neurons. Dewey pointed out that the concepts 'sensory,' 'association' and 'motor' were based upon anatomical, not functional considerations. Actually the arc must be continuous and similar in its function from beginning to end, with no break. That is, the sensory neuron is as much motor as sensory because impulses are headed toward the muscles, and the motor neurons are as much sensory as motor because they are conducting impulses that originate in the receptors. In other words, there is no place to draw the line between sensory and motor functions and no possibility of regarding 'consciousness' as dependent upon one third or two thirds of the arc. The arc functions not in three parts, each part producing a different result, *but always as a whole.* Dewey showed also that through proprioceptive channels and by a change in the organism's orientation, the motor response determines the stimulus as much as the stimulus determines the motor response. The arc, after all, is not strictly an arc but a *complete circuit.*

Neurological evidence supports this view,[13] for not only do muscles contain the endings of motor neurons (end plates) and not only are they innervated by them, but they contain receptors (proprioceptors) which begin to function the instant muscular movement commences. A response barely begins, therefore, when it supplies stimuli for itself. In addition the sensory neurons leading into the cord from the receptors of the body send off collaterals that connect with adjacent motor

[12] *Psy. Rev.,* Vol. 3, 1893, 357 ff. Also *J. Philos. Psy. and Sci. Methods,* Vol. 9, 1912, 645–668.

[13] Herrick, C. J., Introduction to Neurology, 3rd ed., 1924, 247 ff.

neurons over short circuits, so that before the original nerve impulses reach the higher brain centers secondary impulses have caused incipient muscular movement.

Conscious behavior obviously depends upon a discharge of energy from the brain. The presence of short circuits back to the muscles would indicate that in all conscious behavior before this discharge occurs, *there is an incorporation of an incipient response into a larger one.* This is in direct contrast to the view that the motor half of the reflex arc functions under the influence of a simple sensory stimulation at one end and acts only as an innervator of the muscles at the other end. On the contrary, it supposes that the reflex arc, so-called, is under the control of sensory stimulation *at both ends.* The motor end also functions as a stimulus because of sensory excitation from incipient movement. All this shows that the reflex arc functions not as a structure divided into three parts but as a complete unitary circuit. In the development of these views, Dewey and Herrick were anticipating configurational principles.

(2) The Absence of Preformed Pathways. We have seen that the reflex arc concept is illogical. If this is true, the implications to which it leads are of course also illogical, for example the hypothesis that for every reflex performance there is a system of preformed pathways. This assumption is necessary if reflex action is a mechanical performance at one end of a neural arc, caused by a disturbance at the other end, but the assumption obviously does not provide for the formation of *new pathways or for the re-organization of old ones.* The pathways that function at any one time must, therefore, have been preformed, according to the reflex hypothesis.

That the notion of preformed pathways is open to question finds confirmation in the following example, given by Koffka. According to the conventional hypothesis, the infant's first eye-movements (or for that matter all eye-movements) are fundamentally reflex in character. They depend upon the formation of specific pathways from the retina to the muscles of the eye, by way of the optic nerve, the brain centers and the several motor nerves leading from the base of

the brain to the eye muscles. It can be shown that at a certain period in his development, an infant will *for the first time* follow a light with his eyes, without practice, and without making random movements. Let us suppose that, with respect to the infant's head, a light is brought into the position S (Figure 68). He turns his eyes toward the light and follows it as it is moved to the position T. No practice is necessary. Then suppose that the light is placed in the initial position S′ and moved to T′. The situation is quite different; an entirely different set of preformed pathways would be necessary to explain *this* movement, for the eyes are in a different initial position; when focused upon S′ the muscles on one side of the eyes are relaxed and on the other side they are contracted; when the eyes are focused upon S, the situation is reversed. Moreover, different retinal patterns are stimulated in the two instances. A little care will lead to the clear cut observation that there is nothing whatever in common between the two movements except the distance traversed by the eyes. The balance of muscle tensions during the movements is entirely different in the two cases and the stimulus-patterns are different. All this means that the supposedly performed pathways by means of which the movement is controlled must be different in each case. Now suppose that we start at any point between S and S′ and move to any position along a line between T and T′; in each instance a different pattern of preformed pathways must be assumed. In short, no two of these situations are alike, either in functioning of the muscles or in the retinal patterns; to account for the results on the basis of reflex action one must presuppose the existence of a preformed pathway for every conceivable eye-movement. Thus, there would be of necessity an infinite number of pathways which is a logical absurdity and a physical impossibility. Indeed, the principle of preformed pathways will not explain

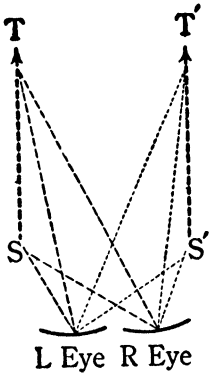


FIG. 68. DIAGRAM SHOWING HOW EYE-MOVEMENTS ARE NOT TRUE REFLEXES (see Text).

any new or old movement of the skeletal muscular system. On the contrary, eye-movement is controlled by a gradient of stimulation. The retina contains a region of highest irritability at the fovea and an area of lowest irritability at the periphery; there is a fovea-to-periphery gradient. Let a light be exposed in the periphery of vision against a background of objects. The light is the point of strongest stimulation. Eye-movements are initiated whenever the point of strongest stimulation does not fall upon the point of greatest irritability. In other words, the equilibrium of the visual apparatus is disturbed and is not established again until the strongest visual stimulus coincides with the most sensitive region of the retina. Eye-movement in any other direction than toward the strongest stimulus in the visual field would be away from rather than toward the establishment of equilibrium within the eye-motor system. In each case the eye-movements are directed by the gradient of irritability; and occur in the line of least action.

(3) **Problem of Summation of Separate Reflexes.** The inadequacy of reflex action as an explanatory principle is shown in other ways. We have already pointed out a difficulty with the logic involved in the use of the concept of reflex action, namely, the impossibility of explaining the whole in terms of its parts. A typical illustration of this point is found in the behavior of Blanschko's frog that would not attempt to escape from a pan of water heated gradually to boiling. The frog's higher integrating centers had been removed, and *yet its body reflexes were intact.* If certain spots on the skin were irritated by a pain-stimulus reflex contractions of that part took place. *But when all of these parts taken together were subjected to painful excitations the frog did not make movements of escape.* This indicates that reflexes do not combine and points to the conclusion that the higher integrating structures necessary for complex behavior are those capable of producing a *different type* of response. The same conclusion is suggested by the behavior of Bechterew's bird when it alighted on a hot perch; it would lift first one foot and then the other, *but would not save itself by flying away; the reflex movements of both legs failed to combine.*

We can best describe complex behavior, therefore, as configurational, because its chief characteristic is its own organization. It makes use of the same muscles and works through the same lower centers that are involved in reflex action, but both the muscles and the lower centers function in a *new and different way* under the control of the higher centers. Indeed, if reflexes combined in a fashion that would account for the more complex types of behavior, one would hardly suppose that additional brain centers would be necessary; connections in the reflex centers themselves should suffice.

Earlier in the chapter we noted how one of Lashley's rats showed a persistence of the maze-habit after the motor areas and caudate nuclei had been destroyed, but, in the habit, there suddenly developed an entirely new set of movements never before employed in the maze-situation. When the rat found it impossible to make a left turn she rotated 270 degrees in order to reach the goal. This could hardly have been reflex action controlled by preformed pathways! If so, one would have to assume that there are preformed pathways ready to function in an infinite number of novel situations that may be brought about by injury of any kind whatsoever. Moreover, the principles of frequency, recency, pain and pleasure were not applicable because the conditions for their operation were not satisfied. The conditions for the functioning of the configurational principle, however, were satisfied. The animal had a goal and not being able to reach it one way, she possessed sufficient insight to reach it another way, for without practice in the situation she made rotating movements with reference to the goal.

(4) The Chain-reflex Theory of Motor Co-ordination. For a long time the theory has prevailed that the functioning of proprioceptors is necessary in the learning and maintenance of muscular co-ordination. Once a muscle begins to contract or relax, the movement stimulates the proprioceptors which in turn send impulses to the central nervous system. These impulses are supposed to determine in part the further contraction or relaxation of the muscle. In walking, for instance, the various degrees of muscular contraction and relaxation with the legs in any given position (contraction of flexors and

relaxation of extensors or *vice versa;* see page 308) condition proprioceptive impulses which guide the muscles in the next stage of the movement. In talking, the movements of articulating one word or part of a word are said to produce stimuli that in part determine the next articulation and so on. This general procedure of maintaining continuous or 'seriated' movement is known as the 'chain reflex.' Hence the chain reflex theory presupposes that there are units of motor co-ordination in the form of simple reflexes that combine into 'chains,' and that sensory stimulation is vital in linking one of the simple reflexes with another.

Lashley's Work on Rats with Lesions of the Spinal Cord. Lashley and Ball[14] trained a number of rats to make perfect performances in a maze with eight blind alleys. Then, by an operation, lesions were produced in the spinal cord. In four rats the lesions interrupted the ascending proprioceptive tracts that connect with the cerebral cortex (*fasciculus gracilis* and *fasciculus cuneatus*) and also destroyed the main motor tracts (pyramidal). In two other cases the ascending tracts were destroyed without extensive injury to the descending routes. In two subjects the lesions were confined to the ascending tracts but were less complete than in the other cases. In three rats other injuries were produced, including the tracts that connect the muscles of the body with the cerebellum. There were in all ten operated subjects. The operations in every case resulted in disturbances of motor co-ordination and in some instances proprioceptive sensitivity was obviously defective. After recovery from the operation some rats with each type of lesion were able to traverse the maze without making significant errors. By running the rats in absolute darkness, visual cues were eliminated; by washing the maze thoroughly, olfactory cues were also eliminated; and the character of the maze was such that cutaneous and auditory cues, according to Lashley, could not have functioned in place of the kinaesthetic. The investigators conclude, therefore, that the maze habit is not a series

[14] Lashley, K. S., and Ball, Josephine, "Spinal Induction and Kinaesthetic Sensitivity in the Maze Habit." *J. of Comp. Psy.*, 1929, Vol. 9, 71–106.

of kinaesthetic-motor reflexes, but that a central 'mechanism' of some kind is capable of guaranteeing an integrated sequence of movements in the absence of sensory cues, *once the movements have been learned.* Such a view as this is quite opposed to the doctrine of conditioned reflexes and the building up of motor co-ordinations by means of the exercise of synapses.

A forward reaching study like this merits serious consideration. It points to the conclusion, first, that motor impulses from the brain to the muscles of the body found their way over other routes than those which, in all probability, they traverse in normal subjects, namely the pyramidal tracts. Second, it leads to the assumption either that sensory impulses, so-called, also find their way to the brain over other than the most direct routes, or else that sensory impulses are not essential to motor co-ordination. It seems likely that sensory impulses from the muscles do not play the rôle ascribed to them by the chain-reflex theory, a point which Lashley stresses. On the other hand, it is unlikely that motor co-ordinations would take place in the complete absence of all proprioceptive stimulation. If extra-proprioceptive cues were eliminated, as they apparently were, it is reasonable to assume that less direct routes from the muscle to the brain remained and that a sufficient amount of kinaesthetic sensitivity was left to 'inform' the animal of its whereabouts in the maze, otherwise the animal would have no way of 'knowing' how far it had gone, whether it had turned to the right or to the left and so on. In other words the goal must be perceived continuously in its relation to the total maze situation. If all sensory cues had been eliminated, as Lashley suggests, we are forced to the highly questionable assumption that the rat was able to perceive the goal and guide itself through the maze exclusively by means of processes which, for the lack of a better term, we may call 'central imagination.' Lashley describes the possible situation as follows: The habit is represented in the brain by an *engram,* a central organization of some kind in which the direction and succession of turns are recorded. We suggest the alternative theory that the animal was still able to perceive the goal and orient itself to it in a general way, through the functioning of receptors. The configurational view

does not require that each muscle contraction be guided by local proprioceptive stimulation, but that the organism-as-a-whole is guided by a perception of the stimulus-pattern as a whole. Since the latter is changing as the organism approaches the goal, some means of perceiving that change in orientation is necessary, and proprioceptive stimulation undoubtedly plays an important part in this connection.

(5) Child's Theory of Physiological Gradients. In Child's[15] opinion the primacy of the whole is a principle which holds for the entire physiology of the organism. Now the spherical shape of an object is caused by an equal pressure exerted upon it from all directions. Apples are round, also potatoes and many other objects that grow, because the environment supplies equal pressure on all sides. This explains also why tree trunks are round instead of square. So also, embryos of higher organisms develop into spheres at first; then when they have reached a certain stage of development they begin to elongate, still maintaining certain aspects of their original sphericity. They become cylindrical; they develop various cylindrical parts such as fingers, arms, trunks, and legs; they grow stomachs that are round, intestinal tracts that are cylindrical, heads that are round, eyes that are round, and so on. The converse of these statements is also true; distortions of an organ and even of the body-as-a-whole occur when unequal pressure is exerted upon them from different directions.

These spherical and cylindrical organic structures exhibit certain patterns of irritability called *physiological or metabolic gradients.* The simplest spherical organisms show as-a-whole a *surface-interior gradient.* That is, the greatest effect of a stimulus occurs at the surface; the surface excitation is transmitted to the interior with a relatively rapid decrement. As the developing embryo assumes a cylindrical shape there forms an *apico-basal gradient* the length of the body, with the point of lowest irritability at the tail-end. The higher and more

[15] Child, C. M., *The Origin and Development of the Nervous System.* Chicago Univ. Press, 1921. Cf. "The Beginnings of Unity and Order in Living Things," in *The Unconscious, a Symposium* (Dummer, Ed.), New York, 1928, A. Knopf, 11–42. *Physiological Foundations of Behavior,* New York. Holt, 1924.

specialized senses, the brain and other organs of high metabolic rates, differentiate at the head-end. Meanwhile, the body-as-a-whole retains its surface-interior gradient. *Further growth processes are characterized by the development of numerous other gradients of various degrees of permanency and subordination to the two primary gradients, all of which provide greater and greater complexity in the relationship of parts of the organism to the organism-as-a-whole. Nowhere in the physiology of the organism is there anything taking place which corresponds strictly to reflex action or to the building up of a whole from its parts; parts are of later development; the organism-as-a-whole comes first.*

We can now understand the position which we took with respect to the problem of inheritance (pages 110, 174). Conventional theories of inheritance throw no light upon the problem of physiological unity and order. The primary physiological gradients are determined by the physical relationships sustained by the organism to its immediate environment. This fact can be demonstrated by cutting a primitive organism in two. The exposed surface, formerly within a surface-interior gradient, then takes on the characteristics of the surface, that is to say, a characteristically high metabolic rate. Gradients can also be controlled by light, oxygen supply, electric currents and local injuries. Thus it appears that they arise new in each generation and that unity and order are not inherent in living tissue but are reactions to the external world. If determinants or genes play a part in directing the growth of the organism, they represent potentials which are realized only through and by the direction of environmental influences.

(6) The Character of the Organism's First Movements. The reflex hypothesis assumes that the primary and simplest movements of the organism are discrete units of the reflex type, just as the older association hypothesis assumed that the primary experiences of the organism were mental elements or sensations. Recent experimental work in embryology by Coghill, Tracy[16] and Swenson establishes the fact that

[16] Tracy, H. C., "The Development of Motility and Behavior Reactions in the Toadfish" (*Opsanus tau*), *J. Comp. Neur.*, Vol. 40, 1926, 253–370. Coghill, *loc. cit.* Swenson, unpublished thesis. Work motivated by Herrick.

reflexes and other specialized activities of separate parts of the organism are relatively *late* developments. The first movements to occur involve only the muscles behind the head because the rest of the body has not yet developed. As the embryo advances in age, movements extend farther along the body toward the tail, but *at each step in the developmental process, the organism-as-a-whole executes the movements.* The next movements of the embryo are a bending of the body to one side or the other; later there is an 'S' type of movement which in rapid sequence results in locomotion. Fin movements in the toadfish (Tracy), leg movements in *Amblystoma* (Coghill) and in the rat (Swenson) occur at first only as part of a general body movement, under the control of those nerve mechanisms that activate the body as a whole. When these appendages first acquire the ability to respond to a local stimulus, the trunk is also brought into play. Local movements, then, are secondary and emerge from the total reaction of the animal by a process of individuation. At first, the limbs can act only when the trunk acts.

The various procedures by means of which the organism-as-a-whole determines the functioning of its parts has been worked out in considerable detail by these investigators. Before the nervous system begins to take form, metabolic gradients have developed which not only condition the position of the nervous system but the direction of its growth. Then, before the muscles of the body have completely differentiated, neurons send out their axons from the spinal cord and brain and are ready to bring the muscle cells into functional relation with the total organism. Trunk muscles develop first, and certain of the motor neurons that grow out to these muscles send off branches to the limbs which develop later. This explains the original subjugation of the limbs to the trunk, for their nerve connections are branches from neurons already integrated with the trunk. Independent movements of parts of the body develop only when the nervous system becomes more highly differentiated.

Sensory neurons send out fibers first to the muscles, and then branch to the skin. The original fibers are therefore both muscle-sensory and skin-sensory, and the instant they begin

to function they are already integrated with the body-as-a-whole; they are differentiated out of the whole and hence retain their membership character in the total configuration.

These facts alone render the reflex hypothesis untenable, but more difficult still for the reflex theory to explain is the fact that *the embryo's body movements commence before the sensory half of the nervous system has developed.* The organism's first movements are not only general and undifferentiated, but are elicited by internal factors!

Carmichael's Experiments. Carmichael [17] has studied the development of behavior in the embryos of the frog and salamander after they had been removed from the influence of external stimulation. Before the embryos showed signs of activity they were placed in a solution of chloretone, which does not prevent maturation, but inhibits activity. A control group was retained in ordinary tap water. When the control group had reached the free swimming stage the drugged organisms were placed in fresh water. After a short period, during which the anaesthetic was wearing off, the experimental group was moving about as freely as the others. In order to ascertain whether this period of delay was a time required for the elimination of the drug effects, or a period of rapid learning, Carmichael anaesthetized another group of embryos and performed the experiment as before, except that he returned them again into the chloretone for twenty-four hours. When placed in fresh water a second time the period of initial inactivity was as long as before, hence it was concluded that the delay did not involve learning. A further check on his results was obtained by letting one group of embryos develop in a noisy room, another in a quiet corner of the laboratory and another in a sound and light proof room. When the first two groups had developed free swimming movements he quietly entered the sound proof room and suddenly flashed a light upon the vessel, whereupon the organisms darted around with the same speed of movement as those in the outside dishes where constant stimulation had prevailed. These results show in gen-

[17] Carmichael, L., "Development of Behavior in Vertebrates Experimentally Removed from the Influence of External Stimulation." *Psy. Rev.*, Vol. 33, 1926, 51–58. Also *Psy. Rev.*, 1927, Vol. 34, 34–47, and 1928, Vol. 35, 253–260.

eral that the behavior patterns studied were the product of maturation, not of exercise.

(7) Recent Work on the Neuron: The All-or-none Law. As we have seen, the earlier work on the functioning of the single neuron *versus* the functioning of a chain of neurons led to a sharp distinction between the two and to an emphasis upon the synapse as the seat of nervous integration. More recent and careful investigations by Adrian, Forbes [18] and others show that what holds for the synapse holds also for the entire neuron. The difference between the two is a relative matter which, of course, renders the principle of the synapse theory questionable, for whatever we say of the one we must also say of the other. One of the outstanding discoveries of this recent work is the *all-or-none response;* whenever a nerve-fiber responds, it responds maximally throughout. Now it is possible with a galvanometer to measure nerve conduction by its own action-current. The fibers along a section of the nerve are partially anaesthetized; then the action-current produced at that place is measured and found to be decreased. But by the time the impulse reaches a very short distance beyond the anaesthesized region it exhibits normal strength again, thus indicating that the decrement has been made up. *All this shows that neural activity is not graded at the synapse, and that if the nerve impulse passes the synapse at all and is cut down at that point it will become maximal again before it reaches the next synapse.*

(8) Lashley's Work on Monkeys and Rats. Lashley's work on rats and monkeys should be mentioned again in connection with the physiological basis of behavior. It will be recalled that the Cebus monkey opened a latch box with its left hand that had been paralyzed while its right hand was being used in the original learning process. Lashley performed a similar experiment on rats. He destroyed both visual areas and then blindfolded the left eye of a rat while it learned a simple visual-motor habit. The rat was then able to carry out the performance perfectly when the blindfolds were reversed. Since learning a performance with one

[18] Adrian and Forbes, "The All-or-nothing Response of Sensory Nerve Fibers." *J. of Physiol.*, 1922, Vol. 56, 301–330.

eye obviously makes use of many synapses not employed at all when the performance is executed with the other eye, the synapse theory falls down. The same situation is emphasized in a more striking fashion in the case of the paralyzed hand. *In both cases, synapses never before used in a given situation functioned perfectly the first time.* (We saw the same to be true in case of eye-movement in the infant.)

The Status of the Reflex Theory. From the foregoing discussion it is evident that the reflex theory of behavior is entirely inadequate. It is logically untenable and is inconsistent with the facts. For example, as can be deduced from a study of embryos, walking is not a combination of local reflexes of the limbs; each limb is integrated with the trunk. Local movements emerge through an individuation process and not as an integration of independent units. These movements may be likened to the emergence of a quality upon a ground. And local independence of parts, or so-called local reflexes, are not reflexes in a strict sense of the term, for the individualization of the special nerve patterns that control these parts is anticipated in the central nervous system by the growth of a nervous organization from which the special patterns emerge as integral parts. The central organization develops with reference to the special pattern long before the latter makes its appearance in behavior (Coghill, page 91). The central system governs the individuation process and permits the specialized parts only a limited individuality of their own. The work of Coghill, Tracy, Swenson and Child modifies the work of Sherrington and Pawlow as a basis upon which to construct a physiological theory of behavior, and configurational principles supplant the laws of association, including the laws of exercise and effect.

Coghill's Theory of Maturation *versus* 'Exercise.' Nerve cells develop and multiply according to a definite pattern which follows its own laws of growth, and the pattern is established before excitation or 'exercise' begins. Accordingly, exercise is neither directly nor indirectly the cause of growth and differentiation of the nerve cell. Growth is the expression of an intrinsic potentiality of the cell. This potentiality is not exhausted when the cell assumes the function of conduc-

tion; indeed, growth and differentiation probably continue through the lifetime of the organism, until the decline of old age sets in. A study of *Amblystoma* shows that a growth of axon and dendrite terminals over a distance of less than one one-hundredth of a millimeter changes the organism from a helpless, passive condition to an active, exploring creature! Growth, then, even of microscopic dimension, will profoundly affect the organism's behavior. The neuron does not become simply a conductor in a fixed mechanism; its maturation is sufficient to account for learning. In other words, the form of the behavior pattern is conditioned by growth, and exercise or experience has nothing specifically to do with the determination of the behavior pattern.

On the other hand, the experience of the individual plays a rôle in determining the differential sensitivity of sensory neurons. Here specificity seems to be conditioned by an interaction of the stimulus with a growth process in the neuron. In brief, laws of growth determine the behavior pattern, but specific sensitivity is fixed by the mode of excitation (105).

Once conduction paths are established it is possible that excitation directs the growth process along specific lines; experience determines when and to what extent the potentiality of behavior shall become actual in a definite performance. *Hence the organism does not learn by experience, but with it. Every new experience arises out of an interaction between excitation and the growth potentiality of the nervous system. The growth potential is primary and excitation and conduction are secondary. The maturation potential is 'at once the inventor and operator' of the nervous system. Learning and the creative aspect of thought are growth processes.* The point of view from which we have presented the facts of behavior agrees in all essential respects with Coghill's theory.

Summary of Physiological Basis of Behavior. *First,* the brain as a whole functions in the execution of any given performance. Lashley calls this the *equipotentiality of function* of the cerebral areas. *Second,* it is doubtful if there is any *definite* or *permanent* localization of function in the higher brain centers. Temporary disturbances of behavior produced

by brain operations are ascribable to the fact that the shortest routes to the brain from a particular mass of receptors, such as the retina, have been cut off. There are other and longer routes which probably function along with the shorter ones, forming a gradient, but the destruction of the shorter ones eliminates the gradient, preventing integrated action until a new gradient can be formed and adjusted to pre-existing gradients. *Third,* within limits which have not as yet been determined, a certain area of the cortex may vary in function from time to time depending upon the behavior of the organism at the moment. (Lashley.) *Fourth,* behavior is permanently disturbed if a sufficient proportion of the entire mass of the cerebral cortex is removed. These facts point to the theory of mass action from one section of the nervous system to another. We may presume that relatively strong stimulation of a given region increases the potential at that region. Energy will then flow *over the shortest routes* to whatever parts of the nervous system at that time possess low degrees of potential. Other things being equal, regions of low potential nearest the high potential area will receive the effect first. Those motor or discharging areas having the lowest potentiality at any given time will receive the excitations and transmit them to the cord. It will be remembered that a rough application of this theory was made in connection with the phenomenon of apparent movement. *Fifth,* neural and behavior patterns are expressions of a growth potential. In turn, the lines of growth are directed by gradients of metabolism. Specific organs and their functions emerge out of fundamental gradients by processes of individuation. *The laws of behavior are not primarily, if at all, laws of exercise, repetition and nerve conduction; they are laws of growth.* Presumably the growth potential may be likened to a tension which resolves itself in approaching a remote end. Specific evidence of this hypothesis is seen in the extension of neurons into regions of two metabolic rates, in the embryonic development of the nervous system. It is seen in the manner in which the central nervous organization anticipates the development of specialized parts of the organism and the special nerve patterns which are to assume partial control over them.

We may relate these general considerations to our concept of human behavior as a process of resolving tensions. At any given time, a certain set of stimuli produce neuromuscular tensions by means of collaterals to the sympathetic nervous system and through short routes back to the external muscles of the body. These tensions determine the high potential areas of the brain. No action results, however, until special low potential areas are established. We may consider the goal to be represented by high potential areas, in which case its effectiveness as a stimulus accrues from its relationship to other stimuli of the pattern. Somewhere in the nervous system the stimulus-pattern is represented by a gradient, the goal being represented by the highest potential and stimuli that are removed further and further away being represented by lower and lower potentials.

The tension-producing stimuli and the goals at any one moment are determined by the differentiation of structure at the receptors, by the maturation of various organs of the body, by the temporary physiological condition of these organs and by the pattern of stresses existing at the moment in the central nervous system.

Our dearth of knowledge forbids us to speculate much further. We can merely point to possible lines of development. *First,* as Watson [19] points out, there is a rough proportionality between the magnitude of the stimulus (size, intensity) and the magnitude of response. Slight stimulation will produce a small contraction of musculature and a stronger stimulus will produce a more vigorous and widespread response. Grading of muscular responses is a function of the number of nerve fibers bearing impulses to the muscles at any one time. A grading of this kind would be conditioned almost wholly by the external stimulus.

Second, work on the refractory period suggests that different neurons transmit successive impulses at different rates. The same neuron will transmit successive impulses at different rates at different times. This rate is an important factor not only in controlling the intensity of the response, but in de-

[19] Watson, J. B., *Psychology from the Standpoint of a Behaviorist,* 1st ed., 1919, 120.

termining the direction of conduction from one part of the nervous system to another. In other words, periodicity of discharge within a certain region, rather than anatomically defined conduction paths, plays an important part in the development of new integrations.[20]

Third, very important is the recent work on the development of configurational response in the embryo (Coghill, Tracy, Swenson). There are chemical methods of demonstrating the gradients which determine the growth of specialized parts of the organism, and already much progress has been made in ascertaining the details of the various processes of individuation. The finer work remains to be done, especially on the precise manner in which the central nervous organization of the embryo anticipates and determines the specialized patterns before they are exhibited in the form of behavior.

Fourth, the duration of an exciting stimulus necessary to produce a reaction in irritable tissue distinguishes one kind of tissue from another; the threshold or intensity of excitation is not the criterion of differentiation. It is known that the excitation time (chronaxie) of a nerve correlates with the excitation time of the muscle which it innervates; that is, the sensitivity of muscle to specific excitation from its nerve depends upon the relation of their excitation times. It is possible that muscles 'impress' their chronaxie upon sensory cells, and that sensory cells have a like effect upon central neurons (Coghill). Then the conditions which determine the excitation time of the neuron play a part in conditioning nerve integration.

Fifth, a suggestion regarding the mechanism by which the nervous system integrates the effects of stimulation of different kinds of receptors may be found in the Rohon-Beard cell which first articulates with a muscle cell and then sends a branch to a skin cell. Evidently the neuron fuses excitations from skin and muscle receptors. There are more complex cells of similar type in the brain (pyramidal cells; Betz cells) which apparently fuse excitations reaching them over other neurons. According to the mode of stimulation impinging

[20] Cf. Lashley, K. S., *Psych. Rev.,* 1924, Vol. 31, 369–376.

upon them (not upon their location) they perhaps develop specialized functions so long as the particular kind of stimulation is maintained. It is conceivable that if their mode of stimulation is changed, their specificity of sensitivity is also changed. This principle would account for Lashley's results on learning in the rat when various areas of the cortex were removed. At any rate these cells probably develop new dendrites and possibly new axons, hence giving rise to a multiplicity of grades of sensitivity, making more and more complex behavior possible (Coghill 101 f).

While a great deal of the experimental work on the nervous system has been done under the influence of incomplete working hypotheses and has therefore been inadequate, the student of physiological psychology should be encouraged rather than discouraged, because the faster mistakes are corrected the sooner will the desired knowledge come to light. New or at least modified working hypotheses should be substituted for the old and as we have seen, striking advances have already been made. Among these working hypotheses is the concept of least action. Its fruitfulness will undoubtedly lie in the fact that it will guide investigators more definitely in the direction of the conditions which are actually determining the functioning of the nervous system. In the past, too great an emphasis upon anatomical structures and their locations—the bias of structural analysis—has led to incompleteness in research and to the faulty conception that parts are primary.

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CHAPTER XVIII

SUMMARY

Assumptions Pertaining to Scientific Procedure. The present study of human behavior commenced with a few simple and fundamental assumptions that were maintained throughout the text.

1. Science deals with events, particularly with those events that it can predict and control.

2. These events are reducible to a common denominator, energy. The ultimate character of energy is by definition unknown and unobservable. Accordingly, the facts of science are not concerned with 'matter' or with 'mind' since these, also, are by definition ultimates and unobservables. The existence either of matter or of mind is a problem for philosophy and is irrelevant to the purposes and laws of science.

3. Prediction implies measurement, for to predict means to specify not only *that* an event will occur but also *when* it will occur, *how long* it will last and how much energy it involves.

4. Science defines events in terms of the conditions under which they take place; it is useless to define any phenomenon in terms of itself.

5. There are two fundamental methods of science, the methods of structural and functional analysis. The former yields descriptions and reduces the analyzed object or event to a lower or simpler order. The latter method yields explanation since it deals with those conditions which preserve the event. Data from the first end in classifications; those from the second lead to prediction and control.

6. The facts with which science deals are abstractions from the world in which we live. Before the abstractions are

made events can not be defined. Once made, however, it is necessary to label and classify them, but these classifications are only convenient pegs on which to hang the facts of observation. Accordingly, the physicist who is interested in a particular class of abstractions labels his facts of observation as physical; the economist regards his as economic; the biologist defines his in terms of living organisms, and the psychologist interprets his in terms of conscious organisms. These scientists are not dealing with economic, biological, psychological and physical *substances;* they are dealing with varieties of events of the same ultimate order, reducible to the same basic laws. Nevertheless, there are special problems associated with the particular sets of events in which each of the scientists is interested.

7. Assumption 6 implies that the world which the scientist investigates is an *organic whole.* The concept of a whole naturally implies the concept of parts or members. This raises a difficult problem: What is the relationship of the whole to its parts? There is a mechanistic theory which implies that the parts explain the whole, but this type of theory neglects an important feature of the whole, namely its *organization* or *unity* which its parts, considered alone, do not possess. When parts combine into wholes new phenomena come into existence and the parts lose their identity; when a whole is disintegrated the original phenomenon disappears and new processes of a 'simpler,' lower order, and perhaps more 'specialized,' emerge. Hence the whole, with its inherent organization, must be assumed in the beginning. This statement holds true for any abstracted part of the world which the scientist chooses to study; taken as such the part is in turn a whole which possesses an organization of its own. Accordingly, any given event is a system that affects other systems, and the laws applying specifically to the interaction of systems must often be modified when applied to the interaction of their separated parts. That is to say, entire systems of energy affect one another in accordance with their own peculiar organization of forces.

The Plan of the Text. In the light of these assumptions it was logical to begin with a study of the immediate

whole of which the human being is a part, namely, the social group. This was not done from the standpoint of the group, but from the standpoint of the individual, for the former study is more properly of interest to the sociologist. The same assumptions introduced the concept of the organism-as-a-whole in terms of which the science of psychology was defined as the study of conscious behavior, or the behavior of the total organism. But it was found impossible to ascertain all the facts about behavior without isolating its various features for specialized study. The concept, organism-as-a-whole, implied the concept of behavior-as-a-whole. Strictly speaking, an organism does not exhibit different *kinds* of behavior, but any single performance is sufficiently complex to necessitate descriptions from a variety of standpoints, depending upon the particular controlling conditions which are chosen for emphasis. If conditions remain unrestricted the subject matter proves to be social behavior; when the conditions are isolated and controlled the resulting behavior is of a 'lower' order, and also more specialized.

The text began with a study of those conditions which most obviously control the unrestricted individual. The plan was then to limit the conditions of behavior gradually *in order to disclose increasingly specialized modes of response.* In other words, the organism was investigated first in an unlimited environment and finally, when an elimination of its external environment had been effected, there remained for inspection only the physiological conditions of behavior, found within the organism itself. In general, therefore, the procedure was that of working from the whole toward its specialized parts, or from the complex to the simple.

The first step in the limitation of behavior was to disregard society as a conditioning factor. This done, it was found that the most obvious aspect of the resulting behavior was its *intelligent* character. There was nothing essentially new about this behavior, for the conditions that were selected merely emphasized a particular feature of the total organism's activities which had already been observed under social behavior. Thus, intelligent and social behavior are not different *kinds* of activities; they are characteristics of any response

which the organism-as-a-whole makes under unrestricted conditions. An intelligent reaction was defined as a response to an object in its relation to a total stimulus-pattern. The procedure in making a response of this kind is first, the construction of a perceptual configuration in which the object is sensed with reference to the total situation. Second, the organism directs its own activities in accordance with this configuration, and the latter always involves an object apprehended as a goal.

The individual's behavior was then limited still further by selecting for emphasis only those conditions which control the *energy or vigor* of his reactions; they are the internal organs and the autonomic nervous system. These same conditions determine to an extent what objects and situations will at any one time function as the goal, but more particularly they disclose *emotive behavior,* which was defined as a response whose characteristics are conditioned by the *autonomic nervous system and the organs which it supplies.*

Next, the conditions were chosen that determine the organism's goal and the distribution of his efforts to reach it, a procedure which introduced the subject of *learning.* In this connection it was proved that distributing the efforts to complete a given task increases the apprehension of the goal and produces more complex movements toward it. Hence learning takes place with respect to a goal that is always becoming more detailed and definite.

While the learning process was being studied it became evident that *observing* was one of its outstanding features. Observing is the process of constructing a perceptual configuration of an object in its setting. The next step, therefore, was to limit the conditions of behavior in such a fashion that perception was isolated for specialized and detailed investigation. Still, observation had been encountered in studying social behavior. The more general aspects of observing were examined first and then its more specialized and limited forms. The more general forms consist of perceiving objects as wholes, while its more limited varieties consist of perceiving *special characteristics* of objects or situations, like color, brightness, tone, odor, taste, temperature, pain and pressure.

The outstanding conditions responsible for modes of behavior of this latter type pertain to the receptors and the nature of the physical forces that function as stimuli. Again, no new process was disclosed, for the behavior studied at the outset involved seeing, hearing and other specialized perceptions. But the finer details of these processes had not been segregated and analyzed. The next step in isolating the more special conditions under which behavior occurs limited the discussion to the *nervous system.* First, its genetic development in the animal scale was reviewed; second, the adult human nervous system was examined both from the standpoint of its structure and of its function, and third, studies in the development of the nervous system in the embryo were surveyed and found consistent throughout with organismic principles.

The Organismic View and its Consequences. The view of behavior held throughout the text led to important consequences. It is called the *organismic* view because any performance of the intact, total organism is emphasized as an *organic whole.* Accordingly, behavior at large consists of events or activities best defined by the most obvious and dominating of the conditions which control it; these conditions are social. The organismic view suggested the fundamental law in terms of which to interpret behavior, the law of least action; it also made a physical as opposed to a psychic conception of behavior unnecessary because action and energy were regarded as neutral terms implying neither matter nor mind. In applying this principle to particular modes of behavior constant use was made of the concepts, *goal* and *configuration,* because action takes place with respect to a remote end, within a configuration of stresses, whether that action is studied from the standpoint of the sociologist, the psychologist, biologist or physicist. It is ascribable to a differential of potentials, of stresses or tensions as the case may be. It proceeds over the quickest and shortest route toward the point at which an equilibrium would be established. The particular alignment of energy in any given system determines the position of the end and the direction of the action. The end of any particular performance of the organism, therefore, is the point at which an equilibrium of neuromuscular tensions is

established, together with a balance between the forces of the organism and the external stimulus-pattern. These tensions are induced by a combination of external and intra-organic stimuli. Indeed, in terms of the conditions for least action, behavior is an effort of the organism to resolve tensions. Just as a body on its way toward the center of the earth exerts pressure upon the ground, so an organism continues behaving in any one situation until it has reached the point at which its tensions disappear; this point is the goal. As long as the goal is beyond reach the organism strives toward it. There are many ways in which the goal is approached by an organism so highly differentiated and specialized as the human being; in fact, the entire text has been concerned with its multitudinous forms.

The concept of configurational response relates first, to the process by which the organism perceives a pattern of stimuli. In its reaction to any given situation the organism perceives an object in its relationships. This object, perceived in its setting, is the goal toward which the organism moves. The relationships may be described either as simple and concrete or as complex and abstract as the case may be. They need not be perceived or interpreted as such, or analyzed by the behaving organism. The term *insight* was employed in characterizing organized response at the level of conscious behavior. Configuration denotes *second,* the type of motor reaction which the organism makes as a consequence of its perception of the stimulus-pattern. Once the situation is perceived and the goal is established, the motor co-ordinations are already effected; they take care of themselves; no special muscle training or exercise is necessary, although by chance it may assist the organism in developing its insight.

These Principles Applied to Behavior: (1) *The Whole as a Condition of Its Parts.* The principles of configuration and least action refer to *systems* of energy, not to unrelated, discrete and separated objects; *they apply to wholes which determine the activities of their parts.* The corollary that the whole determines its parts was demonstrated throughout the study of behavior. In its most obvious aspects, the social, it was found that the behavior of human beings is a product of

society; the whole of which the individual is an integral part determines the outstanding characteristics of his behavior; indeed, the individual derives his human nature from group life. There could be no plainer confirmation of the principle. The specific group influences which thus control the behavior of the individual are folkways, mores, taboos, institutions and other cultural factors. Leaders, it was noticed, arise when the group is confronted by a crisis or when an individual, through his superiority over others, is able to elicit a response from the group. It was found, also, how the group situation stimulates certain fundamental wishes or tensions in the individual and how personality depends upon the manner in which the individual resolves these tensions. Since the principle holds for social behavior in general it would be expected to hold for whatever mode of response a limited set of conditions happened to disclose. The first abstraction was intelligent behavior, a study of which bore out the expectation.

It was discovered that intelligent behavior passes through a gradual process of evolution in the animal scale and that, according to a prominent theory typified in the work of Loeb, the beginnings of behavior are mechanical, tropistic adjustments of the total organism to forces that are acting upon it from without. While the supposition that the organism is a passive victim of these forces did not prove acceptable, the implication that the organism's responses occur in the line of least action served as a consistent point of departure. Then it was noted how the paramecium modified its behavior in a capillary tube (Bentley). There was nothing in the way of interpreting this fact as a resolution of tension. In studying the crawfish (Yerkes), however, the hypothesis seemed even more reasonable that the total organism was determining its own movements in accordance with configurational principles. The avenues to the aquarium were an integral part of the situation which involved the aquarium, and the correct route was learned in its relationship to the total stimulus-pattern. But in goldfish (Wheeler and Perkins) the importance of the whole in giving significance to its parts was clearly observed in the fact that the fish responded to a single light as a member

of a configuration. It was evident that the compartments which they avoided in securing their food were as important in controlling their actions as the compartment in which they were allowed to eat. Most striking of all was the fact that they learned a changing combination of lights quite as readily as they learned a stereotyped combination. Lewis had previously obtained the same result with chicks, and Helson and others, while they had not carried their experiments so far, had noted that changing the physical properties of the stimuli without changing their constant relation failed to inhibit correct responses in the rat. Additional and more detailed evidence of the same principle had come to light still earlier in experiments by Köhler on apes. The manner in which the ape employed a stick depended upon the total situation in which he saw it, and what he accomplished with a box in his effort to secure fruit above his reach depended upon the configuration in which he saw the box. If he could see it simultaneously with the fruit, the box became a means to the end of securing the fruit, but if another ape was lying on the box, it was an object to lie on also, not a tool for obtaining food. The configuration determined the functioning of its parts.

The same principle also obtained in emotive behavior. The particular balance of tensions which constitutes the total behavior of the individual determines how he shall react emotionally in any particular situation. Emotive behavior is an act of the organism-as-a-whole toward the end of preserving its unity although the end need not be consciously interpreted. Various exciting stimuli produce tensions and tensions are the forerunners of disintegration. In his effort to resolve these tensions the individual attempts to maintain his unity and the proper balance of his parts. Accordingly, in resolving the painful tension of suffering blame he rationalizes; in balancing the tension of an inferiority complex he develops conceit; in resolving a sex tension he interests himself in religion or social welfare work where he finds an opportunity to gratify his desires 'vicariously' in preaching sermons or in helping others in difficulty. In relieving a tension induced by a rival he fights; in resolving the tension created by a dangerous

situation he expends his energies in various methods of escape; and in balancing the strain of perceiving his child in distress he hastens to the rescue.

In the learning process the whole also determines its parts. Learning by wholes proves more effective than learning by parts; massed efforts are inefficient because too frequent repetitions destroy the unity of the performance. The ease with which the learner apprehends parts in their relation to the material as a whole measures his rate of progress. In so-called transfer of training it is the organism-as-a-whole that learns a particular performance; it is not a limited part or organ. Lashley's monkey opened a latch box with its left hand as readily as with its right, although the left hand was paralyzed by a brain operation when the motions were being learned with the right. Ewert's subjects traced a pattern with the left as well as with the right hand after learning the performance with the right, except for the awkwardness that is generally observed in left handed persons.

The principle was plainly revealed in a study of perception, and again in an analysis of the most highly specialized performances of all, namely, seeing color, hearing tones, experiencing pressures and the like. The facts of illusions, binocular rivalry, space perception and apparent movement abound in examples. The total effect of a background of radiating lines in the Hering parallel line illusion makes the parallel lines appear to diverge in the center. Words of many letters can be seen as wholes although the same number of letters haphazardly arranged can not be apprehended in a single glance. Errors in proof are missed in perceiving the word as a whole; movement is seen when two successive stationary stimuli give rise to a simple, unified experience; a gray disc is observed as red when it belongs to a figure formed by red discs, and is seen as green when it is a member of a green configuration. Finally, in a study of the nervous system the importance of the whole in determining its parts was especially significant. The first and simplest movements of the embryo are those of the organism-as-a-whole with the organism-as-a-whole directing the development of its parts. The same principle is illustrated in the all-or-none law, in the work

on learning in animals with various parts of the cortex removed, and in physiological gradients. It was revealed in a striking way in studies in the development of the nervous system in embryos.

(2) *The Law of Least Action.* The law that the whole determines the functioning of its parts is a corollary of the law of least action, because the latter implies a total and *unified system* in which there is for the time being a lack of equilibrium of forces. In social behavior the individual conforms to the manners of the group in avoiding contempt and criticism. The non-conformist, on the other hand, is one whose thinking surpasses that of the group and whose striving for new and higher goals of social life is stronger than the tensions produced by the attitude of the group toward him. Moreover, groups as wholes protect themselves from outside groups in various ways in order to resolve tensions of fear and suspicion and to relieve the strain of competition. These are the most direct courses of procedure in arriving at goals.

Intelligent behavior is the resolution of a tension produced in a problem situation. It is an effort to reach a goal when the action toward the goal involves perceiving it at the moment in its relationship to the total situation. It involves the discovery that a certain pathway is the route to food, that a stick is a tool with which to secure food out of reach, that a stone will make a tool for grinding, that a certain set of movements will bring one to the solution of a mechanical puzzle, or that a particular line of thought will lead to the solution of a mathematical problem. Until the goal is reached the organism continues to respond to it, unless another goal is substituted. The processes that take place are the most direct in time, beginning with the conception of the problem and ending with the solution.

Emotive behavior furnishes a striking illustration of the conditions of least action in human behavior. It is all the more striking because of the *effort* expended in reaching the goal and because of the abnormalities of behavior that so often develop when the goal is imaginary instead of real. The high degree of tension exhibited in emotive behavior is caused in part by intra-organic stimulation induced by the autonomic

nervous system. The vigor of emotive tensions depends also upon the expenditure of 'stored energy' within the organism. This energy is being accumulated and used at all times and under all conditions in the maintenance of organic unity. A supplement to the conditions of least action was suggested in this connection that, energy is required to preserve the unity of a physical system under any and all conditions in proportion to the complexity and specialization of that system. Any energy system resists disintegrative influences, and emotive behavior is a striking case of this general law. In the simplest energy systems resistance to disintegrative forces is equivalent to the energy applied from the outside, but in the case of behavior, 'stored energy' makes the resistance disproportionate to the energy of the stimulus.

The law of least action was illustrated again in learning, when the organism always chose the shortest and quickest route to the goal, once it was perceived; it was demonstrated also when the animal made persistent efforts to reach the goal. In this connection it was noted how various investigators of animal learning had measured different tensions by the employment of electric grills charged to different voltages, or by recording the *distance* covered by animals in a checkerboard maze, or by measuring the length of time animals spent in eating, or by recording the order in which less desirable routes to food were eliminated. Then, it was noted how simple movements directed toward an object were unintelligible except on configurational grounds.

Observational behavior exemplified the same principle of least action. Obvious and interesting cases of it were found in the perception of apparent movement, especially that of *delta* movement or movement back toward a weaker stimulus from a second and stronger one with a return to the second stimulus again. It was brought out that long ago Donders and Listing employed this principle in their laws of eye-movement. Further illustrations appeared in the Talbot law of fusion, also in Cermak's parallel laws, which relate the laws of fusion to the laws of apparent movement. The conditions for least action were also illustrated by rotating a disc with a black radial band. According to the mechanical

summation theory the revolving disc should appear darker in the center and gradually lighter toward the periphery, but instead, it presents a homogeneous gray surface. Finally, the roundness of cutaneous 'spots' was interpreted according to the same general law.

Lastly, the functioning of the nervous system suggests the same principle. The law was helpful in understanding how six pairs of external eye muscles could be co-ordinated in bringing the eyes to focus upon a moving object. In this connection a fovea-to-periphery gradient on the retina was posited (Koffka). Then, movement in the line of least action consisted in bringing the dominating visual stimulus upon the most sensitive portion of the retina. Lashley's work, mentioned in the preceding section, indicated that nervous integrations are shifts of energy from high to low potentials over the shortest possible routes, and that learned habits are lost only while nerve energy seeks for itself other shortest possible, but *organized routes,* after the originals have been destroyed. Delays in recovery are evidently caused by traumatic shock and by the *resistance offered to new formations of stresses by preexisting systems.*

(3) *The Control of Action by a Remote End.* The principle that action is directed by a remote end is also assumed in the law of least action; it is implied in the statement that every tension demands resolution. 'Remote end' in behavior refers to the goal the reaching of which establishes an equilibrium within the organism and between it and the stimulus. Thus the hungry animal seeks food until he finds it, the sex driven animal seeks a sex object, the paranoiac is constantly attempting to avoid an imagined persecutor, and the normal individual is persistently seeking approval of the group. Special consequences of this law are to be noted in phenomena of memory and forgetting. Lewin found that his subjects remembered interrupted better than finished tasks, and explained memory on the basis of a striving toward the goal of finishing the task. The same principle was adopted in accounting for the errors made in recall. It was supposed that forgetting is an effort to reach a goal in the absence of a majority of the original stimuli. That is, forgetting is an

active, not a passive process; the subject resists forgetting and is showing every evidence that he is attempting under practical handicaps to learn more about the absent object. In a study of apparent movement it was shown that the observer perceives nothing until a total situation is presented, and presumably a special low potential area established in addition to a high potential area, the two areas figuring in a wave-front that travels across the brain. In other words, the *end is established before the perceptual act begins.* In fact *this law is general; a goal is always established before any mode of behavior commences.* In a discussion of thinking, it was presumed with the configurationists that a given thought process is determined by its solution and that any act, like comparative judging, choosing or reasoning, is a single, unified performance from the moment the goal is constructed to the time it is reached.

The Genetic Development of Group Behavior. It was noted in Chapter II how Kunkel and Chapin regarded the social group as a dynamic agent in the evolutionary development of man. Society not only makes possible an accumulation of 'biological gains' by giving man mutual protection and by preserving a greater proportion of offspring, but it stimulates the development of language, thinking, and the invention of tools. Social behavior exhibits itself at the outset in the form of simple folkways which develop first, as a consequence of perceiving events in their simple, temporal relationships, and second, as a consequence of fulfilling a wish or alleviating a fear. As the insight of the group develops, folkways become rationalized and formally justified. This raises them to the level of mores, and finally, when mores have definitely demonstrated their usefulness or expediency they become laws.

The Development of Social Behavior in the Individual. Mores, folkways and the like were studied as social conditions of individual behavior. When the interaction process between the group and the individual was examined more strictly from the standpoint of the individual certain definite effects upon him were noted in the form of social attitudes. He developed specific attitudes toward leaders, or toward the

masses if he happened to be a leader himself; he developed attitudes toward other races and outside groups; he accepted the group ways and participated in crowd behavior. The influence of the social group on the development of personality and on the individual's concept of self was more interesting from the standpoint of individual psychology. The sensory processes, to which the introspectionist reduces consciousness of self, differentiate and evolve into ideas of self in accordance with the character of a person's social surroundings. The foundations of personality are laid in infancy when the facial expressions of the mother, the manner in which she handles the infant, the tone of voice which she uses, and the like, determine the character of his first reactions. The attitudes of others toward the growing child develop in him traits of shyness or aggressiveness, and within rather wide limits, alertness or stupidity. Indeed, human nature in all its aspects is molded by the personalities that constitute the individual's social environment.

The Development of Intelligent Behavior. In Chapter V efforts definitely to locate the beginnings of intelligent behavior in the animal scale proved unavailing. The behavior of the lowest organisms, however, which Loeb described as tropistic, furnish a suggestive clue. Their behavior evidently follows the line of least action; it is a configurational phenomenon. It was pointed out that the mechanistic definition of tropisms neglected an important feature of the configurational principle as applied to the organism itself, namely, that the organism-as-a-whole is a contributing cause. This fact was demonstrated first in a study of a typical experiment upon one-celled animals in which it was found that the paramecium modifies its behavior. The organism's contribution to the situation manifested itself in two ways, first, in 'perceiving' a goal and in advancing toward it, and second, in modifying its behavior through maturation. These criteria appear in more obvious form in the behavior of the crawfish. But in the goldfish there is no question regarding the rudiments of intelligent response, for they recognize a constant relation between absolute intensities of light in locating their food. This discovery of a goal in its relation to a changing

stimulus-pattern, this perception of a constant relation, compels us to regard their behavior as intelligent, although of a primitive order. It was found that the chick could perceive the goal in more complicated relationships. After learning a combination of seven lights sufficiently to select the brightest or the dimmest, wherever it was, the chick chose the correct compartment when the latter was placed in front of the semicircle of lights in such a position that a sharp turn of the body was necessary to perceive it. A striking advance in intelligent behavior was found in the case of the ape which was able to perceive an object as a tool with which to secure food. The development of insight in primates from the ape to civilized man was revealed in an increase in the use of tools, an evolution characterized by the apprehension of an increasing number of relationships that were constantly becoming more abstract. Language, the domestication of animals, and the beginnings of primitive culture were interpreted as means to ends.

The development of insight in the child shows how essential it is to regard maturation as a basic phenomenon in learning, for his acquisition of language is replete with inventions and with the correct use of words and phrases the first time, in new situations. When adult intelligent behavior is examined introspection becomes necessary to complete the picture, because the modes of response in question are predominantly a use of language and other symbols, especially imagery. It was found that introspection reduces intelligent behavior to various levels of analysis, the more superficial analyses yielding complex 'meanings', conscious attitudes, consciousness of the goal and the like, while the more refined analyses yield sensory processes and imagery. It was emphasized that introspective studies as such do not furnish results leading to prediction and control, but that these results are none the less useful in identifying various kinds of abstracted processes like choosing, comparing, recognizing and reasoning. Introspection also furnishes the conscious setting in which intelligent overt action occurs, and is helpful in comparing behavior at one level of complexity with behavior at another. For example, through introspection, the various

forms of intelligent behavior could be classified for the sake of convenience, according to their complexity, into processes of perceiving, recognizing, judging and reasoning. Analysis showed that an outstanding content marking the difference between recognition and perception was the image, that the corresponding content in judging was the idea, and that the analogous content in reasoning was the concept. Finally, configurational principles were employed to explain all forms of intelligent behavior revealed of necessity by the method of introspection.

The Emotion-Instinct Problem. In a detailed review of the emotion-instinct problem it was established that the mind-body distinction, originating early in the history of philosophy, had given rise to many difficulties. Instinct was gradually separated from emotion in the theories of Hobbes, Descartes, Spinoza and the writers of the 19th century. Then Darwin, James and McDougall attempted to reunite them and to explain their mutual relationship, Darwin by regarding instinctive behavior as expressive of emotion, James by considering it is a cause, and McDougall by assuming both to be aspects of the same underlying process. In the meantime, instinct became a problem in itself and soon evolved to the rank of an explanatory principle, but there were many obvious reasons why the instinct hypothesis was finally abandoned. After the external and social conditions of emotive behavior on the one hand, and the organic conditions on the other, were considered in detail, a theory of emotion was presented in accordance with the circumstances of least action. This theory makes no distinction between mental and physical aspects, since it regards them merely as convenient abstractions from a unified response which is naturally neither mental nor physical. The theory also avoids the distinction between inherited and acquired behavior. There is no more reason for considering any mode of behavior *innate* than for considering *winds* as innate. The concept of inheritance is useful only in understanding the origin of organic structure and even in this connection, the work of Child indicates that many of the characteristics of the organism's structure, formerly thought to be inherited, are products of environment.

The Learning Process. The learning process was examined at considerable length in the light of pre-existing theories of association and also with reference to the configurational hypothesis. The facts clearly indicate that the basic conditions of learning are maturation and stimulus-patterns. These two sets of conditions were compared with two areas of air pressure which, as wholes, affect one another. The level of maturation of the organism represents one set of stresses and the forces of the stimulus-pattern represent the other. The latter system of stresses induces a readjustment of stresses within the nervous system according to the same principle that operates in a meteorological situation where one system of air pressures causes a readjustment in another system. In behavior, the readjustment, seen as a whole, involves the construction of a perceptual-motor configuration in which the goal is perceived in relation to its setting. This procedure also involves the setting up of tensions in the organism which demand resolution in the direction of the goal. The stimulus-pattern forms the configurational response, and the response is made possible by the level of maturation attained by the organism. Since growth of tissues is induced by irritation and pressure, it is likely that maturation is induced by stimulation. Hence learning is conditioned by repeated stimulation, properly timed. However, the explanation of learning rests upon stimulation not upon repetition of response or exercise.

The expression, learning by 'trial and error,' is easy to misinterpret. The learner's random efforts in any learning process are random only with respect to an incomprehensible goal imposed upon him. Only by chance will they bring him into sensible relationship with the goal. If this happens, however, to assert that he learned by experience implies that he made a discovery, that is, exhibited a *flash of insight.* The fact that the insight followed upon a chance performance means that the chance performance is no more a cause of learning than is any other external stimulus. The performance contributed in forming the configuration, but as a chance stimulus, not as an experience. Moreover, the chance or 'trial and error' aspect of the situation is irrelevant; the de*termining feature of the situation is a particular juxtaposition*

of objects that reduces the problem to the level of the learner's insight. Finally, one stage in the learning process is related to the next through the medium of maturation. Indeed, without the factor of maturation, the change from one stage to the next would be unintelligible, because old experiences or old movements will in no way account for the new features of later experiences and subsequent co-ordinations.

The 'Criteria' of Insight. Throughout the text the term insight has been used to describe organized or configurational activity at the level of conscious behavior. Insight implies a qualitative difference between conscious behavior and simpler varieties of configurational activities like those studied in physics, just as water is qualitatively different from either hydrogen or oxygen. But insight is a *descriptive,* not an explanatory term, except as one organized response functions as a condition of another.

The criteria of insight that appeared from time to time throughout the book may be summarized as follows in the order of their generality, with the most general presented first:

(1) The perception of a goal in its relation to a total stimulus-pattern and self propagation toward it.

(2) Changing the character of the goal when stimulus-patterns are repeated (modifiability of behavior).

(3) Consistently responding to novel aspects of situations correctly the first time. The use of a new tool in arriving at a goal; the use of new words and phrases correctly in novel situations; invention.

(4) Responding to the constant but abstract features of changing stimulus-patterns; learning the relatively brightest light of a changing combination; 'transfer' effects.

(5) Sudden formation of configurational responses. Rapid rises or falls in the learning curve, depending upon the fashion in which the curve is plotted; sudden solving of problems when responses were previously controlled by a chance distribution of conditioning factors; sudden elimination of long routes to the goal; sudden abandoning of wasteful procedures.

(6) Periods of *initial delay* prior to the execution of a new performance, that is, hesitating while studying a novel

situation. This is presumably a symptom that the configuration is forming.

Observational Behavior. The more important problems in connection with observational behavior in general were concerned with its conditions, which are commonly known as conditions of *attention.* Among them are mental set and movement or change in the stimulus-pattern. With respect to the latter a law was formulated that the stimulus-situation demanding *new* insight controls the organism's behavior above all else at the time. Then, the problem of fluctuations of attention was considered in the light of Guilford's experiment which showed that the fluctuations are determined by chance variations in the controlling conditions. The range of attention was treated from the standpoint of the configurational hypothesis, using the tachistoscope experiment as an illustration. The more important problems in connection with specialized forms of observation dealt with the conditions of space perception, localization and apparent movement in the different sense departments.

Sensory Processes. Sensory processes, the last abstractions from the behavior of the organism-as-a-whole, were studied from the standpoint of their controlling conditions which were the specialized structure of the sense organs and the nature of the particular physical forces which act upon them. Problems in vision such as quality, adaptation, contrast, after-imagery, color blindness and retinal zones proved so complex that no adequate and comprehensive theory has been developed to explain them. However, many suggestions are available from the more recent attempts of Hecht, Schanz, Forbes and others. The solution of these problems, it was found, carry one far into physics and mathematics. An analogous situation obtained in connection with audition. Many detailed facts are known, some of which have received lasting and widespread recognition. In connection with the temperature senses it was suggested, on the basis of recent experiments by Dallenbach and Waterston, that the prevailing views in regard to the responsible sense organs stand in need of radical modification. It is possible that the same organs subserve warmth as subserve cold, that the number and size

of the 'spots' are dependent upon the condition of the skin and the nature of the stimulus, not upon the position of specialized end-organs. Warm spots are fewer and larger because of conduction of heat; cold spots are more numerous and smaller because of the more restricted process of heat subtraction; the arrangement of the 'spots' in any case is determined by a variety of factors operating together in lines of least action. The same law served as a basis of interpreting the roundness of the 'spots.'

The Nervous System. The structure of the nervous system was studied in order to understand its functions. The problems which were emphasized were concerned with the nature and interpretation of so-called reflex action. Here the same principles which were serviceable throughout the text continued to hold; they received confirmation in the works of Lashley on brain localization, of Child on physiological gradients, of Tracy and Coghill on the development of the nervous system in certain embryos and in Koffka's interpretation of eye-movements. It becomes necessary to regard the notion of rigid localization of function with considerable caution. It is possible that localization of function in the animal scale becomes more distinct as organisms develop more highly specialized sense organs and brains. Human beings suffer relatively more from the destruction of limited areas than the lower animals, but this depends not upon localization of function but upon the greater number of relationships sustained by each area to a variety of surrounding areas. These relationships are more specialized as well as more numerous and are therefore harder to re-establish after an injury. Since the brain is highly differentiated throughout, a reduction in its activity is produced by the loss of a single area. Nevertheless, any loss of function is to be interpreted as an injury to the total system, not as a subtraction of a limited part, with the remainder functionally unaffected. From this standpoint it would be incorrect to regard any one area as the 'seat' of a special mode of conscious behavior.

Views for Which these Principles Are Substitutes. The principles which have just been reviewed are the reverse of the assumptions upon which psychology has ordinarily

rested. Older views for which the configurational principles are substitutes imply that the whole is explained by its parts and that the parts are logically and genetically primary. The earliest attempts of this sort were made by the ancient Greeks who divided the soul into the separate and discrete faculties, intelligence and will. The psychology of the 18th century added feeling, memory, attention and many other faculties. British Associationism developed the principle to its logical absurdity by supposing that the mind at birth was a *tabula rasa* and that it grew by a summative process in which sensations and ideas (refined faculties) formed a unified whole with the aid of a mysterious agency known as association. The psychology of the Continent endeavored to account for a unified mind, similarly composed, first by means of the subconscious and later by means of apperception. The latest systems of psychology to continue the tradition were *first,* the Titchenerian type in which consciousness was defined as the sum total of mental processes composed of the elements, sensation, image and affection. *Second,* there was behaviorism, introduced in its modern form by Watson, who attempted to explain instinctive behavior, habit and learning (all overt action) on the basis of behavior elements or reflexes. *Third,* there was Thorndike's educational psychology in which the learning process was a concatenation of discrete movements or ideas organized through exercise and the influence of pleasure and displeasure.

The concept of behavior-as-a-whole dispenses, further, with the mind-body dualism. It supposes that only when certain features are abstracted from behavior for specialized study are events disclosed that can be called either mental or physical. Then particular processes are called mental purely for convenience, just as the chemist uses the word chemical to mean a special class of isolated events in which he is particularly interested. Neither the terms chemical nor mental refer to special substances or entities. The concept of behavior-as-a-whole rests upon the assumption of the ultimate sameness or oneness of all events observed and studied in science (not psychophysical parallelism), a sameness or one-

ness that can be expressed by the word *energy*. The psychologist is not justified in speaking of consciousness in connection with behavior for the same reason that the biologist is not justified in speaking scientifically of life. And for the same reason the physicist has no occasion to speak of an ultimate material substance, matter. In his thinking, the phrase 'structure of energy' accomplishes everything that the term 'matter' formerly accomplished, and avoids the philosophical assumptions associated with the latter. Consciousness, life and matter are problems for the philosopher, and for the scientist only when he is interested in philosophy.

There is little need, in beginning psychology, for the older concepts of association and attention. Moreover, in connection with social behavior, it was found that instinct, suggestion, imitation and habit are unsatisfactory interpretive concepts. As explanatory terms they not only imply a construction of the whole from its parts but a definition of activities in terms of themselves. The popular notion of intelligence as a fixed quantity, and the constancy of the I. Q., were criticized in this connection. It became unnecessary to attempt an explanation of intelligent behavior, especially of the higher thought processes, in terms of discrete elements, images, thoughts, and the like, for in the view of the text, these experiences are abstractions from configurational responses. The sharp distinction between inheritance and environment in accounting for intelligent behavior was also criticized.

Those theories of learning which rest upon the laws of association, exercise, effect, frequency and recency are considered inadequate because they, also, are inconsistent not only with the facts of experimentation but with the primacy of the whole. Repetition of response sustains the same relationship to the learning process as time sustains to growth; consequently, while it is a constant factor in learning, it possesses no interpretive value. Likewise, retention and recall were defined without reference to impressions and traces; they were considered responses to partly repeated stimulus-situations. Similarly, perception was treated not as a product of sensations and images operating according to the laws of attention

and association, but as a configurational response formed in the line of least action by the organism as a whole, in accordance with the level to which it had evolved and matured. And finally, the whole-part logic was accepted, together with the experimental facts on the functioning of the nervous system, as sufficient reasons for abandoning the concepts of reflex action and preformed pathways. This means, also, that the synaptic theory of nerve integration is of doubtful value. It was concluded, therefore, that the evolution of behavior in the life history of the organism does not rest upon the opening of pathways or the producing of graded resistances at the synapses by means of their use and disuse. Accordingly, the notion of maturation and the formation of configurational responses by total stimulus-patterns were substituted, and specific ways were suggested in which patterns of nerve stresses are formed.

Postword. In the introductory chapter the statement was made that in science theories are as important as facts. Accordingly, to make possible a more complete appreciation of psychological facts, theories have not been slighted. Nevertheless, it should be recognized that theories are not facts, and that they are constantly changing. The standpoint from which this book was written claims justification by the facts of our present knowledge; it is a point of view which is rapidly modifying preexisting theories. It should not be supposed, however, that the suggested hypotheses will continue long in their present form, or that they are wholly adequate. They are working tools whose value is to be measured *first, by the problems* which they raise and by the factual results to which they lead. Unquestionably they will be modified by these results. *Second,* a theory is to be judged by the consistency and thoroughness with which it organizes the known facts into a related whole. This is true whatever the scope of the problem. For example, a theory of vision should explain *all* the facts of vision. Likewise a theory of behavior should organize *all* the facts of behavior. The theoretical aspects of the discussion have been presented exactly with these intentions: To raise problems, to lead to the discovery of new facts, and

to systematize the existing facts with respect to conscious behavior in general. The test of these theories, and the only test, is their usefulness in fulfilling these intentions for the time being.

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APPENDIX

In order to illustrate the application of the statistical measures given in Chapter III we shall take an illustration of the simplest order and indicate the application of our method. Exactly the same principles apply to much more extensive sets of data, although when large numbers of cases are used more exact methods of correlation are better (Product-moment, etc.).

I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Case	Reaction Time	D (from Average)	D^2	Rank	Mental Age	D (from Average)	D^2	Rank	D (of Ranks)	D^2
A	150	9	81	3.5	11.0	0.6	0.36	4	0.5	0.25
B	160	1	1	6	10.0	0.4	0.16	6	0	0
C	140	19	361	2	12.0	1.6	2.56	2	0	0
D	170	11	121	8	8.0	2.4	5.76	9	1	1
E	160	1	1	6	9.0	1.4	1.96	8	2	4
F	190	31	961	10	7.5	2.9	8.41	10	0	0
G	150	9	81	3.5	9.5	0.9	0.81	7	3.5	12.25
H	130	29	841	1	15.0	4.6	21.16	1	0	0
I	180	21	441	9	10.5	0.1	0.01	5	4	16
J	160	1	1	6	11.5	1.1	1.21	3	3	9
Totals $n=10$	1590	132	2890		104.0	16.0	42.40			42.50

Note the table above. We have recorded here a set of reaction-times in thousands of a second (Column II) and mental ages in years (Column VI) of 10 people designated by the letters from A to J (Column I). Reaction-times measure the speed with which a person can respond to a stimulus. (Consult page 328.)

To find the *average* reaction-time, we would apply the formula (1), page 96. In this case n equals 10, and the sum of the measures (Column II) is 1590. Substituting in the formula, we get,

$$A = \frac{1590}{10} \quad \text{or} \quad A = 159.$$

In a similar way we might find the average mental age for these

subjects. In this case the sum of the measures (Column VI) is 104.0 and n is the same. Then,

$$A = \frac{104}{10} \quad \text{or} \quad A = 10.4.$$

In order to find the median of either group of measures we have to put the cases in order from the best to the worst. Notice the ranks in Column IX. The highest mental age, 15.0, is given the rank, 1, and the others in order down to 7.5 which is given the rank, 10. From formula (2), page 97, we know that the median is the case with the rank of $\frac{n+1}{2}$. In this case it would be 5½ or midway between the fifth and sixth cases. The fifth, Case I, has 10.5, while the sixth, Case B, has 10.0. The median would then be 10.25.

The procedure in the case of the reaction-times involves an additional feature inasmuch as a number of cases have the same values. The procedure is the same for the first two ranks, Cases H and C. Cases A and G both have 150, so, in order to treat them equally, we divide the next two ranks between them, giving each 3.5 instead of one, 3, and the other, 4. We can not give 3 to both because we must have 10 ranks to correspond to the 10 cases. Also, B, E and J received the same value, 160, so we divide between them the ranks 5, 6 and 7, giving each one the rank, 6. Thus we see that in this case the median, midway between the fifth and sixth cases would be 160. (A simple method of getting the median is merely to count up or down to the middle case from the end of the column of measures, provided they are arranged in order of their size.)

Having found the averages of the sets of data, we may now find the values of the average and standard deviation. Notice Column III. Here in each case we have found the difference or deviation from the average, 159. Trace down the column and see how each of these values is obtained. The formula for the average deviation may now be applied (page 98). The sum of the deviations in 132 (Column III) and n is 10. Then,

$$\text{A. D.} = \frac{132}{10} \quad \text{or} \quad \text{A.D.} = 13.2.$$

Compare this with the standard deviation. For this each of the deviations must be squared, as shown in Column IV. Applying formula (4), page 98, we get,

$$\sigma = \sqrt{\frac{2890}{10}} \quad \text{or} \quad \sigma = \sqrt{289} = 17.$$

The corresponding values can be worked out for the mental ages. The differences from the average, 10.4, are shown in Column VII, and the squares of these deviations in Column VIII. The resulting values are, respectively,

$$\text{A.D.} = 1.6.$$

$$\sigma = \sqrt{4.24} = 2.06.$$

The values of the probable error both of the distribution and the average may be found in a moment from the standard deviation. Applying the two formulas (5) and (6), page 99, we get the following results for the reaction-times.

$$\text{P.E.}_{\text{dis.}} = .6745 \times 17 = 11.47.$$

$$\text{P.E.}_{\text{av.}} = \frac{.6745 \times 17}{\sqrt{10}} = 3.63.$$

The corresponding values for the mental ages are 1.39 and 0.44.

Finally, we want to find the coefficient of correlation between these two sets of data that we have hitherto treated independently. For this purpose we have already ranked our material. In case we should not have done that, it would be necessary to stop and rank the data at this point. It should be noted that the original, raw data *can not be used* with this formula.

Given the two sets of *ranks* the first step is to find the differences between the two ranks in each case. (See Formula 7, page 101.) Thus, in our table, Column X represents the differences in the ranks that we find in Columns V and IX, respectively. This may be followed across for each case. The second step consists of squaring these differences, the results to be found in Column XI. Now we are ready to apply the formula. The sum of the D^2 column is 42.5, and n is 10. Then,

$$\rho = 1 - \frac{6 \times 42.5}{10 \times (100 - 1)}.$$

$$\rho = 1 - \frac{255}{990}.$$

$$\rho = 1 - .258.$$

$$\rho = + .742.$$

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GLOSSARY AND SUBJECT INDEX

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Acquired insight; insight that has evolved, not by means of experience, but *as* experience, 221

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Automatic writing; executed while the subject is in a trance or abstracted state of "consciousness," 284
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Autonomic nervous system; that part of the nervous system which controls the vegetative functions (glandular secretions, functioning of the internal organs) of the body relatively independently of the brain centers involved in conscious behavior, 78. See Nervous system.
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Bi-molecular action; a certain type of chemical action pertaining to two molecules, 398
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Canals, semicircular, 413
Capacity, inadequacy of term, 20, 171
Cardiac muscle; heart muscle, 216
Catalepsy; nervous affection characterized by coma, muscular rigidity and plasticity; that is, a part of the body like the arm or leg will remain in a position in which it is placed by an external agency, 64
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Cauterization; burning or searing (of tissue) with a hot metal, 474
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Cerebrospinal fluid; a watery fluid filling the ventricles of the brain and the canal within the spinal cord, 113. See Brain.
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Chronaxie; the minimum effective duration of an electric current in producing a response in irritable tissue. The current is double the amount barely necessary in eliciting the response. Given the name "excitation time" by Lucas, 499
Cilia; small mobile appendages on the surface of primitive organisms by means of which locomotion is achieved and food taken into the "mouth," 120
Ciliary muscle; small circular muscle surrounding the lens of the eye, important in accommodation, 383
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Closure phenomenon; name applied to the termination of a motor response or a thought process when regarded as the resolution of a tension or the establishing of an equilibrium, 154
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Collodial suspension; a physical state in which "particles" or temporarily fixed patterns of energy are suspended in a semi-solid mass, 478
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Complementary colors; colors that cancel each other and leave a gray when mixed, as in a color top or motor; antagonistic colors, 21. See Color mixture.
Conation, as conative element of will, 176
Concatenation, a series of things or events united like links, 170
Concept, 146–149; defined, 146; uses of the, 146
Conception; the process of understanding a situation, achieved with the aid of concepts or abstract ideas, 138
Configurational hypothesis, as substitute for other views, 521–524
Configurational psycholgy; that type of psychology which emphasizes the organized character of all responses of the organism, recognizes the primacy of the *whole* and explains the parts in terms of the whole. Opposed to the atomistic and structural tradition of accounting directly or indirectly for the whole in terms of its parts, as in trial and error learning, in perception and thinking. Parts—specific mental processes and muscular movements—are regarded as devoid of properties except as they acquire them from larger wholes. A *Gestalt* psychology.
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Constancy hypothesis; the assumption of a one to one correspondence between aspects of the stimulus and aspects of the organism's response; the assumption that organisms make discrete responses to discrete stimuli; implicit in any view that attempts to explain the whole in terms of its parts, 348
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Contractile tissue; tissue that contracts (muscle), 446
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Cranial nerve; nerve leading out from lower surface of the brain to the head or to the body (not the spinal cord), 215. See Nerves.
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Cues, memory; processes, involved in recall, that appear to aid the recaller (visual and verbal imagery, etc.); not external stimuli, 274
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Ego; the self, regarded as an entity; empirical, the self as experienced through the senses; transcendental, an inferred self—the experiencer, 48
Electrocardiograph, 225–228
Electro-motive force; electrical potentials set up in the body during muscular contraction; measured by various types of galvanometers, 179
Electro-kymograph; drum revolved by clock works or motor; paper, moving with the drum, is perforated by electric sparks, 231
Electrolytes, solutions containing an electrical charge or potential, 478
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Entity; something regarded as a thing-in-itself; an ultimate state of existence or being, 18
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Faculty psychology; a psychology in which mind is said to be composed of discrete parts, entities or faculties that are by nature unreducible; generally refers to pre-scientific psychology, 19
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Fourier's theorem; a mathematical statement of the relationships between the various components (harmonic) of a sound wave (the fundamental and overtones), 400
Fovea, the spot of clearest vision in the center of the retina, 384, 455
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Galton whistle, 400
Galvanometer; a device for record-

ing and measuring galvanic currents (electric) arising from chemical action, 224 f., 494

Ganglia; masses of gray matter in the nervous system; centers of integration of nerve impulses; practically synonymous with nucleus when situated within the central nervous system, 215. See Nucleus; Nervous system.

Genes; hypothetical chemical compounds supposed to be present in the reproductive cells of living organisms and to determine the various characteristics of body structure in the offspring, 491. See Determinants.

Genetic; pertaining to the origin and development of a trait or an organism, 44, 47

Geniculate bodies; centers of vision and hearing in the thalamus in the interior of the brain, 449; external (vision), 454; internal (hearing), 455

Germ plasm; tissue of the reproductive cells, 110

Gestalt; literally translated, *shape* or *form.* Also translated as configuration. A mental process regarded as an organized or unified pattern of a given form, or structure, that may remain constant while the details of the pattern may vary, *e.g.,* a *melody* played in different keys. The term emphasizes the principle that when mental processes (or motor responses) are studied as segregated phenomena many of their properties are not observed—the whole from which these properties are derived frequently escapes observation. Considered as a response, the *Gestalt* is an organized whole, while the stimulus-pattern which elicits it is an *arrangement* of stimuli. *Gestalt* also refers to organized (configurational) motor reactions of the organism (co-ordinated movements), 23, 276, 364, 375

Gland, pineal, 160

Glands, adrenal, 210–213; pituitary, 214; salivary, 208 ff.; sex, 214; sweat, 217; thyroid, 214

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Goal, the termination or end of a given response, however simple or complex. Used without regard for a sharp distinction between stimulus and response. Represented by those stimuli or objects, in a stimulus-pattern, the reaching of which relieves tension in the organism. Represented in the organism by a relative equilibrium in the neuromuscular system. In thinking of behavior as a goal-activity, the goal is the end or termination of a given act, such as a train of thought. In bringing behavior into relation with dynamical principles, the goal is interpreted as a point in an energy system toward which a body moves under stress; it is the point of low stress of the system, and the organism is regarded as part of the system in which it moves. The goal, however, may be constantly changing as to position, a fact correlated with the mental aspect of behavior (insight). In conscious behavior the goal is perceived, and conditions within the organism determine in large measure what stimulus shall be the goal at any one time. The situation is akin to a gravitation system with its center constantly moving, along with shifts in the alignment of potentials elsewhere in the system.

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Lower order, facts of a; pertaining to aspects or parts, removed from any whole; regarded as "simpler" because the possibilities of further analysis appear to be less as the analysis becomes more refined, 138, 153, 198, 504

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Maturation (of the nervous system); a growth and differentiation process conditioned by nourishment from within the organism and by stimulation of the sense organs by patterns of stimuli; characterized probably to some extent by small increments of growth in the nerve cells, especially of certain types of cells within the brain, after the brain has reached its maximum size and weight, 75, 115, 149, 172, 197, 220, 222, 267, 269, 273, 284, 298, 311, 313, 324, 331, 440, 516; Bird's experiments on, 297; Carmichael's experiment on, 493 f.; conditions of, 321; emotive behavior and, 222; nature of, 319; potential, 497; recess periods and, 298 ff.; *vs.* exercise, 290–300, 495 f. See Behavior, intelli-

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Nucleus (pertaining to the nervous system); a mass of gray matter; a co-ordinating center in the brain; caudate, 449, 470; lenticular, 449, 470
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Plexus (plural, plexi); integrating center of autonomic nervous system, situated somewhere about the body, 215
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Protoplasmic activity, activity of living tissue or protoplasm, 225
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Rohon-Beard cell; primitive type of sensory cell, found in vertebrate embryos; grows outward from primitive spinal cord first to the muscle, and then branches to the skin; supposedly fuses "excitations" from the skin and muscle; a possible prototype of certain kinds of brain cells of special importance in nerve integration (pyramidal, Betz cells), 495
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Stimulus, adequate, 378
Stimulus, change and persistence of, as conditions of observation, 336 f.
Stimulus-pattern, an arrangement or pattern of stimuli, all members of which affect the organism. Not used in the sense of an organized whole that is "planted" in the organism, although the physical arrangement of the stimuli in the pattern play an important part in effecting configurational responses, 40, 77, 78, 84, 125, 173, 253, 267, 337 f., 440, 498; general rôle of, 331; memory and, 271–274; learning and, 311; relation of, to goal, 241 ff.; relation of, to personality, 40. See *Gestalt* and Goal.
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Ventral, under surface of; below; "front" in case of spinal cord in human beings.
Ventricles of the brain, 113, 449. See Brain.
Vertebral, pertaining to the spinal column (backbone), 215
Vestibule, 413
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Vision, bidimensional, 349 ff.; stereoscopic, 351; tridimensional, 351 ff.
Visual purple; a pigment at the tips of the rods, or next to them, which is supposed to facilitate brightness vision and possibly color vision, 397, 454
Vitreous humor, 382
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Voluntary neuromuscular system; muscles that can be controlled voluntarily (striped muscle), (skeletal muscle), plus the nerve

centers (bulk of brain and spinal cord) and nerves, by which the muscles are innervated.

Warmth, paradoxical, elicited by temperatures a few degrees below that of the skin, 438
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Wave, standing; a wave set up when two waves of the same frequency travel in opposite directions in the same medium, such as when a wave is reflected back upon itself; differs from a progressive or traveling wave in that certain of its parts (called nodes) are stationary. The maxima of standing waves are the parts of greatest amplitude, 398
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