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ABILITY AND KNOWLEDGE

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ABILITY AND KNOWLEDGE

THE STANDPOINT OF THE LONDON SCHOOL

BY

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WITH A FOREWORD BY

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MACMILLAN AND CO., LIMITED

ST. MARTIN'S STREET, LONDON

1935

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DEDICATION

TO THOSE WHO
BEFORE MY SCHOOLDAYS, DURING THEM, AND SINCE
HAVE BEEN MY TEACHERS

FOREWORD

Not often, surely, has anyone been more gratified at being invited to associate himself with another's work than I am in penning these few lines of appreciation.

As the Author says, the contents of his scheme largely consist of ideas that he and I possess in common. But in his contribution he has brought to bear such admirable judgment, has made such important additions, and has achieved such simplicity and clarity, that my own share of the work has pride in its present company.

It is a particular pleasure to find at last in this book the long needed confluence of two streams of study, which happen to have had separate origins, but which by nature belong so intimately to each other, that their chief value derives from their combination. The two tributaries are those of general and of individual psychology. My cordial congratulations to the Author who has brought about such a happy union.

CHARLES SPEARMAN

January, 1935

TABLE OF CONTENTS

PART 1. INTRODUCTION

CHAPTER PAGE

1. The Scientific Approach - - - - - - - 1
2. Conscious Phenomena - - - - - - - 7

PART 2. INDIVIDUAL DIFFERENCES IN ABILITY

THE PROBLEM - - - - - - - - - 14
3. Historical - - - - - - - - - - 17
4. The Two Factors Theory - - - - - - - 25
5. The Factors, *g* and *s*
   A; The General Factor, *g* - - - - 33
   B; The *s*'s, or Specific Factors - - - 37
6. *S*-overlap - - - - - - - - - - 42
7. The "Energy-Engine" Hypothesis: 1 - - - 54

PART 3. PERSONAL VARIATIONS IN ABILITY

THE PROBLEM - - - - - - - - - 57
8. The Constancy of Cognitive Output - - - 59
9. Retentivity: 1. Facilitation
   A; Facilitation of Isolated Events - - 68
   B; Facilitation of Paired Events - - - 72
10. Retentivity: 2. Inertia - - - - - - 77
11. Fatigue - - - - - - - - - - 84
12. Variability - - - - - - - - - - 91
13. Control of Cognition - - - - - - - 96
14. Basic Conditions
   A; Age - - - - - - - - - - 102
   B; Heredity - - - - - - - - - 105
   C; Sex - - - - - - - - - - 108
   D; Health - - - - - - - - - 109
15. Illustrative - - - - - - - - - 112
16. The "Energy-Engine" Hypothesis: 2 - - - 116

PART 4. THE BIRTH AND GROWTH OF KNOWLEDGE

CHAPTER PAGE

THE PROBLEMS - - - - - - - - 121

17. CLEARNESS VARIATION AND REPRODUCTION - - - 123

18. THE PRE-HISTORY OF NEW COGNITIONS - - - 131

19. THE APPREHENSION OF EXPERIENCE - - - - 136

20. THE EDUCTION OF RELATIONS - - - - - 146

21. THE EDUCTION OF CORRELATES - - - - - 167

22. *G*, EDUCTION, AND "INTELLIGENCE" - - - - 183

SUMMARY OF LAWS AND COROLLARIES - - 190

PART 5. THE UTILIZATION OF KNOWLEDGE

THE PROBLEM - - - - - - - - - 193

23. PERCEPTION - - - - - - - - - - 195

24. THE INTELLECT - - - - - - - - - 204

25. MEMORY, RECOGNITION AND IMAGINATION - - - 210

PART 6. EVALUATION

THE PROBLEMS - - - - - - - - 220

26. SOME CRITICISMS DISCUSSED - - - - - - 222

A; THE TWO FACTORS THEORY - - - - 222

B; NOEGENESIS - - - - - - - - 232

C; THE QUANTITATIVE DETERMINANTS - - - 241

27. OTHER THEORIES - - - - - - - - - 245

28. THE SIGNIFICANCE OF THE PRESENT THEORIES - - 255

A; THE THEORETICAL POINT OF VIEW - - - 256

B; THE PRACTICAL POINT OF VIEW - - - 260

SUMMARY - - - - - - - - - - 275

TABLE OF APPENDICES

PAGE

APPENDIX 1 - - - - - - - - - - - 276

THE STATISTICAL ARGUMENT FOR THE TWO FACTORS

A ; CORRELATION, AND CORRELATION COEFFICIENTS BETWEEN TWO TESTS - - - - - - - 276

B ; TETRAD DIFFERENCES - - - - - - - 284

C ; CORRELATION WITH *g* - - - - - - - 290

D ; THE TWO FACTORS AND SAMPLING THEORIES COMPARED - - - - - - - - - 293

APPENDIX 2 - - - - - - - - - - - 295

RELATIONS

A ; REAL RELATIONS - - - - - - - - 295

B ; IDEAL RELATIONS - - - - - - - - 297

APPENDIX 3 - - - - - - - - - - - 299

THE DIFFUSION OF LEARNING EFFECTS

APPENDIX 4 - - - - - - - - - - - 312

RETENTIVITY IN THE SPECIAL SENSES
by
Elsa Walters, B.A., Ph.D.

TABLE OF INDICES

INDEX OF NAMES - - - - - - - - - 317

INDEX OF WORKS - - - - - - - - - 320

INDEX OF SUBJECTS - - - - - - - - - 322

ABBREVIATIONS

The following abbreviations have been used in the references which follow most chapters :

NP	*The Nature of " Intelligence " and the Principles of Cognition*, C. Spearman.
AM	*The Abilities of Man*, C. Spearman.
CM	*Creative Mind*, C. Spearman.
BJP	*The British Journal of Psychology.*
BJEdP	*The British Journal of Educational Psychology.*
BJP,PM	*The British Journal of Psychology, Psychological Monograph.*
PM	*Psychological Monograph.*
PR	*Psychological Review.*
JEP	*Journal of Educational Psychology.*
JExP	*Journal of Experimental Pedagogy.*

AUTHOR'S NOTE

It was some ten years ago, during my undergraduate days, that this work was first vaguely conceived. I felt then—in a somewhat impersonal way—the necessity for a simpler exposition of Professor Spearman's theories than that contained in his two major volumes and in the very many articles which have appeared beneath his name in English, American and German *Journals* during the last thirty years. The volumes, though accessible to the beginner and of complete lucidity, are not designed for him ; while, from his point of view, the articles are often too technical and inaccessible. But the idea of writing this book developed no further for a considerable time. I had in those days the advantage of having both Professor Spearman himself and Professor Aveling to expound what at last is set forth here ; and that, to those who know them both, will explain why I never felt the need for such an exposition as this in any really personal way. It was not until I had wandered far from London, and wished to include some of these ideas in lectures to teachers and to Workers' Educational Association Classes, that I realized to the full the gap in psychological literature which these pages seek to fill. Just then I should have been profoundly grateful if someone else had already written this book : as it is I am just as grateful that the honour has been left to me.

First, then, this is an attempt to place before the novice in psychological studies a simple yet adequate and authoritative account of the theories associated with the name of Professor Spearman ; but it also offers the more advanced

student a fairly comprehensive compendium of the most important findings of what has come in recent years to be known as " the London School ". It begins with the problems of ability—the nature of the differences in talent between one man and another, and the nature of personal variations in efficiency. The fundamental processes of acquiring knowledge are then discussed ; and the roles played by these in such more complex processes as those of perception, reasoning, memory and imagination are dealt with. The nature of " intelligence ", so-called, is expounded ; and the practical applications of the doctrines enunciated are also considered. The last Part of the book is devoted to an examination of criticisms which have been made of Spearman's work, of alternative theories, and of its value both to the academic psychologist and to the layman interested in his own mental processes and in those of other people.

I hold it no exaggeration to say that it is as impossible to-day to pretend to knowledge of the universe of things mental without knowing something of this work of Spearman's as it is impossible to pretend to knowledge of the physical universe while knowing nothing of Einstein and de Sitter. The following pages, then, constitute an elementary outline of two theories of possibly " epoch-making " importance ; and one of the most useful services which I have it in my power to perform will be achieved if some readers, after perusing these pages, are thereby inclined to delve into the fuller original presentations for themselves. The chief claim which I would urge on behalf of the present work is its concentration, which has been achieved by the omission of much of the technical evidence but not by that of anything likely to impair an adequate preliminary grasp of the material.

But a word of warning is necessary here. Although Spear-

man has, as I have said, contributed two distinct theories to current psychology, it should be realized from the very first that they are so intimately connected that the significance of neither can be appreciated fully in isolation from the other. This has an important corollary. Although the present work has a "double-barrelled" title it is very definitely a unit, and must be thought of as such. It will be found, for example, that problems are raised in Parts 2 and 3 which are not finally solved until Parts 4 and 5; and the serious student must keep this in mind throughout. Perhaps the chief test of the competence of both reader and writer will be that the former will close this book persuaded that, in the ultimate analysis, the psychology of ability and the psychology of knowledge are one.

But the "serious student" of whom I spoke a moment since is not necessarily enrolled in a W.E.A. Class or even in a University, or Training College, or other Institution where psychology has a place in the curriculum. In recent years the rapid accumulation of scientific discoveries seems to have been largely paralleled by an expansion of lay interest in them. To-day people who—for any of a thousand reasons —are aloof from all organized educational influences, are yet frequently curious about the most recent advances (however tentative and even illusory) in such diverse fields of knowledge as those explored by the astrophysicist, the biochemist, and the psychotherapist. Thus it happens, in the second place, that these lines have been written in the hope that they may make some appeal to this larger audience also.

But to claim, as I certainly do, that the *substance* of this book merits a hearing at least as wide as those which the theories of Infantile Sexuality and of the Expanding Universe, shall we say, have gained, is to invite a multitude of

comparisons, some of which I would prefer at all costs to avoid. May I disarm some criticism in advance by apologizing on the one hand for possessing but the most ordinary literary facility ; and, on the other, for so far having departed from the current mode of conducting intellectual cruises that the last chapter is not devoted to proving the most fascinating thesis that God is a Psychologist. I say this because these pages do differ in two important respects from many which purport to describe other fields of scientific discovery for the enlightenment of the curious layman. My aim has been to present merely the basic facts which confront the student of ability and knowledge, together with the conclusions to which these facts seem of themselves to force him ; but to shun on the one hand merely literary embellishments, and, on the other, all pseudo-philosophical and quasi-theological speculations concerning the nature of mind and its place in the Cosmos. Those who entrust themselves to the present writer will have at least a cautious pilot, content to guide them through waters shallow enough for him to have sounded himself. Those who crave more exhilarating adventures have two alternatives. The more discerning will note for themselves, at different points on our voyage, vistas which challenge independent exploration later—even if the final satisfaction they promise is in inverse proportion to the explorer's own critical acumen. The less discerning are already well catered for. They are advised to patronize other cruises, whose pilots include an evening's excursion into the so aptly termed " Unknown " as a matter of the most ordinary routine.

But the most important feature of these pages, and the one which is most likely to commend them to the reader, has yet to be mentioned. This is the part Professor Spearman himself has played in their preparation, a part to which

it is difficult for me to do justice without seeming to be fulsome. Since the first words were written in 1930 his personal interest has never flagged. I am indebted to him (and the reader, perforce, shares my debt) for detailed suggestions in connection with every chapter—almost, indeed, with every page. He has given time without stint to correspondence and, on the all too rare occasions when it proved possible, to personal consultation ; and I fear lest in these respects my debt to him is greater than such debts should be.

A word must be added here in explanation of the sub-title. It must not be thought that Spearman's have been the only outstanding systematic contributions to psychological theory and practice which have emanated from London in recent years. There has, in notable addition, been the equally original and important work of Professor Aveling. Some account of this also appears in the following pages ; but since it has been concerned chiefly with branches of psychology other than those of ability and knowledge, it follows that far less than justice has been done to it here. It would, however, be highly improper for me to conclude this *Note* without acknowledging the personal debt which I owe to Professor Aveling. Such insight as I have into the matters discussed hereafter is in very large measure the product of his power of lucid exposition and of his patient unravelling of my early difficulties. Again—the reader, perforce, shares my debt.

Lastly, it is essential to point out that the London School differs in one important particular from, say, the Psychoanalytic School. Here, heresy-hunting is not the vogue ; there, one accepts Freud's Holy Writ or is excommunicated and has to found or join a rival school. Thus it is that, in the following pages, occasional departures are to be found from the strict

detail of Spearman's own original presentation. For these the present writer is alone and fully responsible. In number they are very few; and if, on occasion, their occurrence is not noted in the text, it may be assumed that they are such that the advanced student may be trusted to note the discrepancies for himself, and that the beginner would hardly consider them of outstanding interest.

FRANK C. THOMAS

December, 1934

ACKNOWLEDGMENTS

BESIDES giving the assistance to which reference has been made in the foregoing *Note*, Professor Spearman has also been kind enough to contribute a *Foreword*; and this I very gratefully acknowledge here. In addition, there is a long list of helpers who have, in one way or more, gained my thanks and deserved the reader's. In particular I should like to mention some of my colleagues and—though not by name—those most unfortunate wives whose help, I understand, they have willy-nilly co-opted. Dr. E. Benson, and Messrs. E. B. Crampton, B. Johnson, W. C. Kerr, D. G. Murdoch and R. Windross have all made suggestions which forced their own acceptance upon me; and Mr. W. Jones has taken immense trouble in the preparation of Figs. 16 and 18. To my friends Mr. and Mrs. F. A. Bailey I am indebted for more than just critical help, for much of what follows was first written under their roof and in the congenial atmosphere of their hospitality. My one-time fellow student and former collaborator, Dr. Elsa Walters, has somehow found the time to advise on many points, to contribute a much appreciated *Appendix*, and to read proofs; and for all of this, as well as for her continued interest and encouragement, I am profoundly grateful. To my sister, Mrs. Grace E. Burtt Martin, I am especially indebted for the time and care she has given both to proof-reading and to the still more tedious task of compiling the index. And Messrs. J. Fawkes and P. Rodney Pollard, two former pupils, have given most acceptable and appreciated assistance—the former in the preparation of many of the Figures, and the latter in

checking the calculations of the tetrads and coefficients in Appendix I. Lastly, I have also to thank the following authors and publishers for permission to make use of their work:

Prof. C. Burt, Drs. H. Crichton-Miller and W. A. Potts, and the British Broadcasting Corporation; Dr. R. B. Cattell, Messrs. G. G. Harrap & Co., Ltd., and C. W. Daniel & Co.; Dr. William Brown and Messrs. Edward Arnold & Co.; Prof. C. Spearman and Messrs. Methuen & Co., Ltd.

F. C. T.

January, 1935

PART ONE

INTRODUCTION

CHAPTER ONE

THE SCIENTIFIC APPROACH

(Chapter 1 *may be omitted at a first reading.)*

1. Scientific Laws and Hypotheses.
2. Observations of Two Kinds.
3. Complementary Laws and Resulting Tendencies.
4. The Criteria of an Acceptable Law.
5. Conclusion.

1. SCIENTIFIC LAWS AND HYPOTHESES

Most of the pages which follow are devoted to describing two sorts of phenomena. On the one hand we shall take note of those mental events which can, in one way or another, be observed; and, on the other, we shall record the sequences in which these events are commonly found to occur. There is a mode of expression, now so traditional as to be ineradicable, which speaks of such descriptions as the *laws which govern* mental phenomena, as though there were something in addition to, and outside, the mere events and typical sequences which the psychologist observes. There may be. But the purpose of this book is that of positive science, not speculation; and, when phrases like the *laws of the growth of knowledge* occur in the following pages, it must be understood that such laws only summarize certain observed facts about the acquisition of knowledge. In no sense do they represent any things, directive influences, or external compulsions,

extraneous to the facts themselves. In short, scientific laws do, and can do, no more than tell us *what* things happen, and in what order ; they can never tell us *why* they happen thus. Psychological laws describe behaviour and experience. They do not govern them, as the law against bigamy may properly be said to govern the behaviour and experience of a man who would otherwise embark upon a multiplicity of matrimonial commitments.

It seems worth while to illustrate this limitation by considering a well-known physical law. That of gravity, for example, does not tell us why it is that terrestrial bodies tend to fall when unsupported ; it merely records the observed fact that they do tend to do so. Usually, of course, an additional gravitational force is postulated, which is held to " explain " the observed fact of the earthward movement of free bodies ; but it is important to remember that the fact of gravitation is one thing, and the explanatory hypothesis of a mutually-attractive force is quite another. The fact is one of observation, and is verifiable and irrefutable ; but the force is nothing more than the postulate which seemed most satisfactory to the majority of competent people who thought about the matter between the time of Newton and that of Einstein.

In the following chapters several hypotheses will be advanced ; * but the present writer has been at some pains to make clear how much of what follows is observed fact, and how much is merely an attempt at explanation. The facts constitute the basic laws of ability and knowledge ; and are of cardinal importance. We may regard them as irrefutable, provided only that we keep in mind the certainty that some of them will be shown by future research to stand in need of subtler analysis than present investigations have

* In chaps. 7 and 16, for example.

afforded. But the explanatory hypotheses are on quite another, and a much less secure, footing. They are merely thrown in to put the reader in touch with the present direction of thought on the subject. Obviously, they are liable to be abandoned at any time, if further research shows them to be less tenable than others which have not yet been thought of.

2. OBSERVATIONS OF TWO KINDS

We have already spoken of " observing " phenomena and their sequences. But the term *observation* has, in scientific discussion, a much wider connotation than it has in popular usage. In matters of inheritance it is a datum of frequent observation that " like begets like ". We do not seek grapes of thorns, or figs of thistles ; nor do we expect a cutting taken from a red rose to produce yellow ones in a later year. But there are many obvious exceptions to this. Mendel's researches in connection with the common edible pea are particularly well worth considering. He found many examples in which peas with a mixed ancestry bore little resemblance to their parents. By collecting very many such observations, he was able to discover what may be described as the " atomic " or " factor " theory of inheritance. He showed, by subjecting the observations to a mathematical analysis, that the inherited constitution of a living organism is determined at its conception by a group of factors. These are, as it were, dealt to it at that moment, much as cards are dealt to a player at the beginning of a hand of bridge.

Now, although the Mendelian factors of inheritance are not open to verification by direct observation, it must be stressed that they still do not transcend observation. They are " observed " in the sense that their previously unsuspected existence is *revealed* as soon as the multitude of direct

observations is subjected to mathematical analysis. This point is stressed because some of the most important observations in the following pages are of this type.* They are the result of submitting to appropriate mathematical treatment literally thousands of single observations, no one of which by itself would be of the slightest use in the formulation of a scientific law. But the result of doing this is still an observation. Though a remote and not an immediate one, it does not transcend observation.

3. COMPLEMENTARY LAWS AND RESULTING TENDENCIES

A further point is worth noting here. It is that scientific laws sometimes seem to contradict each other. The physical law already mentioned states, among other things, that free terrestrial bodies gravitate, or move earthwards. But although balloons and airships certainly do this once in a while, they frequently do just the opposite. This second fact is one of those summarized by Archimedes' law, namely, that bodies, when immersed in a fluid, are thrust upwards. It follows, then, that the gravitational and Archimedean laws are complementary, and not in any real sense contradictory; and that certain phenomena can be observed which manifest both. If the gravitational law were the only one concerned with the up-and-down movements of terrestrial bodies, nothing would ever rise from the earth's surface at all. If the Archimedean tendency were alone operative, nothing would ever stay there; every mobile object would be thrust upwards indefinitely. The actual flight of a balloon is, of course, a compromise between these upward and downward tendencies.

This is worth stressing here since, in subsequent chapters,

* Particularly those dealt with in chaps. 5 and 6.

two pairs of laws will be enunciated in which superficial contradictions will appear.* They must be examined in their own rights, and the reader must satisfy himself that the contradictions are only apparent, and the laws truly complementary. In cases where, to use the current idiom, a phenomenon "governed" by two laws appears to "obey" neither consistently, it is spoken of as exhibiting a *tendency* to "obey" both. The earlier example from heredity illustrates this. The expression "like begets like" needs many qualifications before it can be regarded as an adequate description of the very complex facts of inheritance. But it remains true that "like *tends* to beget like", even though brilliant parents sometimes have imbecile offspring, and short fathers have tall sons.

4. THE CRITERIA OF AN ACCEPTABLE LAW

In the formulation of a scientific law, three things have to be thought of.

(1) The law must be expressed UNEQUIVOCALLY; that is, it must be couched in language that cannot be misunderstood. For example, any technical terms employed must be defined exactly in non-technical words which, as far as is humanly possible, admit no ambiguities.

(2) It must be of UNIVERSAL application, in the sense of covering all phenomena of the type with which it deals.

(3) It must be FUNDAMENTAL. This means that it must not overlap with another; we cannot have two different laws purporting to describe the same facts.

5. CONCLUSION

Such an introduction as this may be unexpected in a work dealing with psychology. But it is this book's special claim

* *Viz.*, (1) the laws of *constant output* (chap. 8) and *variability* (chap. 12); and, (2) the laws of *retentivity* (chaps. 9 and 10) and *fatigue* (chap. 11).

to attention that it does present unequivocal, universal and fundamental laws which, between them, describe all the phenomena which are open to direct or remote observation in one vast field of mental life. That field happens, too, to have very great practical as well as theoretical importance, for it comprises the two sub-fields of the psychology of ability and the psychology of knowledge. The major portion of the following pages is, then, devoted to an exposition (1) of those laws which describe abilities and differences between abilities; and (2) of those other laws which describe the phenomena of acquiring and utilising knowledge. These two topics, which are approached in the above order, exhaust in its entirety the psychological field known technically as that of *cognition*.

CHAPTER TWO

CONSCIOUS PHENOMENA

(*Chapter 2 may be omitted by readers to whom the terms* cognition, affection, conation, volition *and* orexis *are familiar.*)

1. Conscious and Unconscious Processes.
2. Types of Conscious Experience.
   (*A*) Cognition.
   (*B*) Affection.
   (*C*) Conation.
   (*D*) Volition.
3. Cognition and Orexis
4. Illustrative.
5. The Unity of Conscious Experience.

1. CONSCIOUS AND UNCONSCIOUS PROCESSES

It will be seen in due course * that the abilities which are discussed in Parts 2 and 3 are those in which consciousness seems to play some part. It is, however, held to-day that purely unconscious processes are also active in our mental lives; and that a man's ability to speak in public, for example, may still be influenced by past occurrences which he has so far forgotten that, not by the most strenuous and systematic effort to remember, could he bring them into consciousness again. We shall admit both the truth and the importance of such facts as these, and a place will be found for them in the discussion which follows; for the laws to be enunciated do, as a matter of fact, take account of the unconscious as well as of the conscious elements in ability.† None the less, without in any way distorting the facts, it will

* Cf. p. 16. † For example those dealt with in chaps. 9 and 13.

make things clearer, by enabling the reader to verify many of the more important conclusions for himself, if the conscious aspect is stressed. For this reason, and also because conscious phenomena will occupy us very considerably in Parts 4 and 5 as well, they will now be examined briefly. As for the unconscious processes, their influence is most conspicuous in abnormal conditions, and can best be studied in works on mental disorders and their treatment (1).

2. TYPES OF CONSCIOUS EXPERIENCE

There seem to be three or four quite different kinds of conscious experience, distinguished in common speech by such terms as (*a*) knowing, (*b*) feeling, and (*c*) striving and willing. A few psychologists, among whom the present writer quite definitely counts himself, consider that striving and willing are sufficiently dissimilar to warrant their being regarded as belonging to different types of conscious experience (2). It will, therefore, be held here that there are four distinguishable kinds, and they will usually be referred to by the following technical terms :

(**A**) **Cognition.** *Cognitive* processes are those by which we come to acquire a knowledge both of ourselves and of our environments. At the lowest level of cognition is such a simple process as that by which we become aware that we are cold, that something seen is white, or that a noise is going on. At the highest level of cognition are the much more complex processes by which we pass judgments about abstract ideas ; for example, that all men are mortal ; or that any two magnitudes, each of which is equal to a third one, are themselves equal. Between these levels lie such feats as those by which we come to know that a certain name or face or tune is familiar ; to learn that this object is termed a *book*, and that, a *locomotive* ; to translate a phrase from

one language to another; or to interpret the symbols $\sqrt{\pi}$, and to perform the appropriate calculations.

Cognition, then, is a term which embraces both the perceptive and the thinking functions of conscious mental life. It includes, on the one hand, the relatively lowly activities of becoming aware of what is happening to, and around, us; and, on the other, those more complex activities of thinking about such occurrences during, and even long after, our perception of them.

(B) Affection. Contrasted with cognitive processes are *affective* states, in which feeling, and not perceiving or thinking, occupies consciousness. This term affection is also used to include two kinds of conscious experience. On the one hand, there are the simpler emotions, as of fear, love, anger, disgust and the like; together with states such as those of admiration, awe, gratitude and reverence, in which the simpler emotions are experienced as blended together. Further emotional states to be included under the same heading are still more complex ones, such as those of despair, anxiety, and confidence; regret, remorse and sorrow; joy and happiness. But besides all these, which seem to be linked to the working-out, or thwarting, of specific instinctive tendencies, there are the vaguer feelings of pleasure or unpleasure, which form a constant background to consciousness at all times. These, too, may be classed as affective, although they are to be regarded as functions of the success or failure of any present mental process, rather than as the concomitants of specific instinctive activities (3).

(C) Conation. A third type of awareness is that of states in which we ourselves are active, and not the relatively passive recipients of cognitive or affective experiences. We ordinarily describe these states by such words as "endeavouring", "striving", and "trying"; and the technical

term *conation* is employed to include them all. Conative states, then, are those in which the experience of self-activity in seeking some goal is predominant in consciousness.

(D) Volition. The last kind of conscious experience is that of willing. This is the highly elusive state which can be detected just at the moment when we choose or decide between several alternatives, or give assent to one possible course of action as against another. Commonly, as has been said already, *volition* is not distinguished from conation: but this would seem to be a confusion due to inadequate introspective analysis. When one is lying drowsily in bed on a cold morning, the decision to get up may, or may not, be followed immediately by the appropriate action. If it is so followed, then conation, that is, striving to put the volition into effect, may scarcely ensue at all. If, however, the resolve to get up is not translated into immediate activity, a period of striving to put the volition into effect may occur, to be followed, perhaps, by a renewed decision—a repeated act of will—to get up. But there does seem to be a clear introspective difference between, on the one hand, volition, the mere effortless and transitory decision to do so-and-so, and, on the other hand, conation, the effortful and more prolonged striving to put the volition into effect.

3. COGNITION AND OREXIS

As a last preliminary, it will be of advantage to introduce the term *orexis* and the corresponding adjective *orectic*. These words have been taken from the Greek ὄρεξις, which meant "a longing, or desire, or appetite; an eager striving, endeavour, or longing to obtain anything;" and they are used to include all affective, volitional and conative experiences, and to distinguish them from cognition. In other words, any conscious state may be classed as either

cognitive or orectic ; and this simple bisection of experience will frequently be used later, when the more elaborate four-fold analysis is unnecessary.

4. ILLUSTRATIVE

The following passage, from Hardy's *Tess of the d'Urbervilles* (4), is given as illustrating these terms. Tess, after murdering d'Urberville in the room above, had left the house. Mrs. Brooks, the landlady, knowing nothing of what had happened, and waiting for Tess to return, or for a ring from upstairs, " pondered on the delay. . . . In reflecting she leant back in her chair.

" As she did so her eyes glanced casually over the ceiling till they were arrested by a spot in the middle of its white surface which she had never noticed there before. It was about the size of a wafer when she first observed it, but it speedily grew as large as the palm of her hand, and then she could perceive that it was red. The oblong white ceiling, with this scarlet blot in the midst, had the appearance of a gigantic ace of hearts.

" Mrs. Brooks had strange qualms of misgiving. She got upon the table, and touched the spot in the ceiling with her fingers. It was damp, and she fancied that it was a blood stain.

" Descending from the table, she left the parlour, and went upstairs, intending to enter the room overhead, which was the bedchamber at the back of the drawing-room. But, nerveless woman as she had now become, she could not bring herself to attempt the handle. She listened."

The different types of experience seem all to be clearly differentiated and described in this passage. The following are the most obvious examples of each :

(A) Cognitive. Glanced, noticed, observed, could perceive, fancied and listened.

(B) Orectic.

i. AFFECTION. "Had strange qualms of misgiving."

ii. CONATION. "Could not bring herself to attempt the handle."

iii. VOLITION. "Intending to enter the room overhead."

5. THE UNITY OF CONSCIOUS EXPERIENCE

The analysis of experience which we have just undertaken must not blind us to the essential unity which awareness has. While you are reading these lines your conscious experience is an alloy in which cognitive, conative and affective elements are fused together in different proportions; though the proportions themselves will change during the actual reading. At one moment cognition of the meaning of a phrase will predominate; at another moment it will be conative endeavour to master an elusive idea, which is to the forefront of awareness; later, an unpleasant emotional reaction to some fault of style or to a seemingly disputable assertion may blaze up. But, whichever of these different aspects of experience may be enhanced at the moment, the others nevertheless remain in the background of consciousness. It is not one alone, but the coherence and interpermeation of them all, which constitutes awareness.

An analogy may suggest reasons for the analysis of this unity of experience with which the present chapter began; and may also hint at the lines along which such analysis may be justified. Standing at sunset at the foot of a mountain one can contemplate first one aspect of the scene and then another. The profusion of hues—grey, blending into purple; reds and browns; and the green of the lower slopes—may first be noticed; then the mere bulk, the vastness, the immensity of it all; and, again, the contours—here cutting fiercely into the skyline, there merging softly into a neigh-

bouring range, to become lost in the distant shadows and half-lights. The mountain itself must be thought of as a unity of which colour, size and form are but three of many aspects. But these aspects can be abstracted from the unity ; and we can contemplate each apart from the whole and apart from the others. Such abstractions may have pragmatic value. The boatman on the lake, seeking a familiar landmark before darkness obscures it, will divorce the mountain's form from both its size and its colours. The engineer, faced with the problem of blasting the mountain, will be concerned with its size and form ; its colours, as such, will not concern him.

Not dissimilarly the psychologist finds it of advantage in his work to think at one time of the cognitive aspect of experience apart from the others ; and at other times to ignore the cognitive, and concentrate on one or other of the orectic aspects. We shall find that such an approach has real value in reducing the problems we shall meet to manageable dimensions. It will enable us in these pages to formulate the laws of cognition, which do differ, as we shall see, from those of conation, affection and volition ; just as the physical laws concerned with masses and their equilibrium differ from those concerned with whatever colours the same masses may take on at this moment or at that.

REFERENCES

(1) Excellent expositions are those in *Psychology and Morals*, J. A. Hadfield, and *Psychoanalysis and its Derivatives*, H. Crichton-Miller.

(2) The distinction is due to Aveling ; see, e.g., his *Directing Mental Energy*, particularly chap. 10.

(3) The view of emotion adopted here is that of McDougall, and elementary accounts are to be found in his *Introduction to Social Psychology* (chaps. 3-5) and *The Energies of Men* (chap 11).

(4) Chapter 56.

PART TWO

INDIVIDUAL DIFFERENCES IN ABILITY

THE PROBLEM

The purpose of Part 2 of this work is to state the answers offered by one modern school of psychology to that group of problems which concerns the amazing diversity of human ability. One man is a genius, his mind ranging over many fields of thought, and enriching each. Wilhelm Wundt, the German savant, was such a man. In philosophy, psychology, physiology, sociology, literature and law, he was alike a master. Another man is born so much an idiot, and remains such, that he never masters even the processes of dressing himself.

Hardly less striking than such quantitative differences between generalized supernormality and generalized subnormality are the specific qualitative differences which are everywhere obvious within the accepted range of normality. But the moment the present writer seeks to enumerate some of these differences he is reminded of his own deficiencies in descriptive talent. Fortunately for both reader and writer the latter's task has already been performed by Bernard Shaw in the following cogent words :

> *As I write these lines the newspapers are occupied by the exploits of a child of eight, who has just defeated twenty adult chess players in twenty games played simultaneously, and has been able afterwards to reconstruct all the twenty games without any apparent effort of memory. Most people, including myself, play chess (when they play it at all) from hand to mouth, and can hardly recall the last move but one,*

or foresee the next but two. Also, when I have to make an arithmetical calculation, I have to do it step by step with pencil and paper, slowly, reluctantly, and with so little confidence in the result that I dare not act on it without "proving" the sum by a further calculation involving more ciphering. But there are men who can neither read, write, nor cipher, to whom the answer to such sums as I can do is instantly obvious without any conscious calculation at all; and the result is infallible. Yet some of these natural arithmeticians have but a small vocabulary; and are at a loss when they have to find words for any but the simplest everyday occasions; and cannot for the life of them describe mechanical operations which they perform daily in the course of their trade; whereas to me the whole vocabulary of English literature, from Shakespeare to the latest edition of the Encyclopædia Britannica, *is so completely and instantaneously at my call that I have never had to consult even a thesaurus except once or twice when for some reason I wanted a third or fourth synonym. Again, though I have tried and failed to draw recognizable portraits of persons I have seen every day for years, Mr. Bernard Partridge, having seen a man once, will, without more strain than is involved in eating a sandwich, draw him to the life. The keyboard of a piano is a device I have never been able to master; yet Mr. Cyril Scott uses it exactly as I use my own fingers; and to Sir Edward Elgar an orchestral score is as instantaneously intelligible at sight as a page of Shakespeare is to me. One man cannot, after trying for years, finger the flute fluently. Another will take up a flute with a newly invented arrangement of keys on it, and play it at once with hardly a mistake. We find people to whom writing is so difficult that they prefer to sign their name with a mark, and beside them men who master*

*systems of shorthand and improvise new systems of their own as easily as they learn the alphabet.**

OUR FIRST TASK WILL BE TO INQUIRE INTO THE NATURE OF SUCH QUANTITATIVE AND QUALITATIVE DIFFERENCES IN ABILITY AS THESE. *It is not enough to ascribe them to heredity, as is usual in England; or to environment, as seems to have become the vogue in America. We shall see later that both heredity and environment probably have some share in the differentiation of human talent; but, apart from this, the problems are far too deep, complex and subtle to be dismissed so casually.*

Only one preliminary remains. This is to point out that we shall confine our attention to those abilities which seem to involve conscious intervention on our own part, at any rate in the earliest phases of their development. We shall not, for example, be concerned with a man's ability to digest his last meal. Still, it will be found that even those of our talents which seem to us most completely mental, appear always to have a physiological side to them as well; and, though much less is known about this aspect than about the mental, we shall make use of such findings of the physiologists as are relevant. In particular it will be necessary to mention, from time to time, the central nervous system, and one at least of the several endocrine *glands, about which there is so much talk to-day.*

* *Back to Methuselah*; Preface.

CHAPTER THREE

HISTORICAL

1. Monarchic Views.
2. Oligarchic Views.
   (*A*) Faculties.
   (*B*) Mental types.
3. Anarchic Views.
4. Conclusion.
5. Summary, and Alternative Nomenclature.

The task of accounting for observed individual differences in ability is one that has excited much speculation and controversy. The contradictory views which have been advanced to explain why Tom should be a pavement artist, Dick a pickpocket, and Harry an eminent politician, are almost as many as the psychologists who held them; but they may be classified fairly adequately into three or four main groups.

1. MONARCHIC VIEWS

In theories of the monarchic type, "intelligence" is regarded as the monarch, or sovereign power, of the mind; and the various theories of this type differ only in the way they define the term "intelligence", if, indeed, they define it at all. Such views are commonly held in non-technical literature, and in popular usage; "intelligence" being equated to native common sense, or the ability to deal appropriately with the concrete problems of everyday life. At the opposite extreme "intelligent" has been regarded as synonymous with "intellectual", the "intelligent" person being, roughly, one who displays exceptional talent

in the logical manipulation of abstract ideas. In biology it has been regarded as an animal's power of adaptability to new situations; and, by teachers and employers, it is taken as the equivalent of "educability", for that is all that is meant by saying that so-and-so is "bright" or "stupid" in his class or at his work (1).

The common factor in all such theories as these is clearly that "intelligence" is a single supreme power of the mind, and that some people possess more of it than others. It could well be termed, as it sometimes is, "general ability"; for it is always regarded as affecting everything that its possessor does, and as limiting his success at it.

Such a view seems to present two great difficulties.

(1) Scarcely two psychologists can be found who will agree to the same definition of the term "intelligence".

(2) It completely fails to account for the fact that a man may be pathetically stupid and infantile in the vast bulk of his mental processes, and yet may be a genius at one. This occurs most often, perhaps, in the realms of musical executancy and professional sport.

2. OLIGARCHIC VIEWS

Contrasted with views of the monarchic kind are others in which abilities are regarded as determined by a number of separate talents, or by a person's mental type. Such views maintain that ability is, as it were, governed by an oligarchy, or ruling clique, of two or more discrete mental powers.

(A) Faculties. In one important traditional view, the mind is regarded as little more than the sum of a number of diverse faculties, and this view has by no means been wholly abandoned yet, even in technical literature. Spearman catalogues the faculties accepted in 33 prominent publications of the present day (2). They are as follow:

Faculty	Number of Times Advocated	Source
Memory	19	Taken over from ancient psychology.
Intellect	16	
Sensory perception	15	
Imagination	11	
Attention	10	
Movement	6	
Language	3	
Various	16	New

It has to be added that many authorities divide and subdivide these faculties, often in considerable complexity; some finding several kinds of memory or imagination, for example, when others, equally authoritative, are content with only one.

In such views of ability as these it is held, for example, that a man may be good at remembering, bad at intellectual processes, of a mediocre imagination, and so on, throughout the whole list of faculties accepted by the particular authority holding the view. But we have already noted that there is no agreement as to how many such faculties exist. In addition there is convincing evidence that even those which are most widely accepted do not behave as units. One man may remember names, but not faces; another's visual imagination or memory may be vivid and effective, while his auditory imagination or memory may be feeble in the extreme; and so on through the whole of any list of faculties. But another objection is even more damaging. It will be seen later that all these so-called "faculties" are no more than complex products of the same few simpler cognitive processes.* But even without anticipating later chapters, it must be obvious to the most casual glance that the processes of, say, language, memory and intellect are to a large extent identical.

* Cf. Part 5.

(B) Mental types. In doctrines of mental types it is said that there are alternative contrasted qualities which characterize every one of a person's mental processes to a greater or a less extent. Such a view is that people tend to be either "subjective", concerned mainly with their personal relations to things, or "objective", concerned rather with the things themselves. Another such view divides people into so-called "deep-narrow" and "broad-shallow" types; a third into "introverts" and "extroverts"; and a fourth into "surgents" and "desurgents".

It is fairly obvious that not only the monarchic, but also the faculty views of ability, are sharply contrasted with such views as these of types. The two former stress the quantitative aspects of ability, the first offering to explain Robinson's all-round superiority, and the second why Smith excels at golf, although Jones plays better contract bridge. On the other hand, the doctrines of mental types ignore the quantitative aspects of ability entirely, and emphasize the qualitative. For example; Jung says of the introvert that, "In thinking out his problems to the utmost of his ability, he also complicates them, and constantly becomes entangled in every possible scruple. The subject perceives the same things as everybody else, only he never stops at the purely objective effect, but concerns himself with the subjective perception released by the objective stimulus. The peculiar nature of introverted intuition, when given the priority, also produces a peculiar type of man, viz., the mystical dreamer and seer, on the one hand, or the fantastical crank and artist, on the other" (3). Extroversion, the same writer says, "means an outward turning . . . a manifest relatedness of subject to object in the sense of a positive movement of subjective interest towards the object" (3). Cattell describes the surgent mentality in the following terms, "A

fluency of association, a quickness of response, and a ready 'leaping-up' of ideas and impulses" (4).

Four comments on such views as these seem worth making.

(1) However accurate and penetrating they may be, they require for our purpose supplementation of a purely quantitative kind.

(2) It has to be confessed that, in practice, they are not particularly useful, for unhappily most people do not fit readily into such clear-cut divisions as these. Most of us might better be described as "hybrid" or "mongrel" with respect to such types, displaying clearly, in our everyday reactions, several of the contrasted characters of each type.

(3) It is seldom, if ever, that in such doctrines of types the distinction is drawn between the cognitive and orectic factors which are held to typify the contrasted classes of person.

(4) Superficially there does not seem to be very much agreement as to what types actually exist, or as to their precise characteristics. Each observer seems to favour an oligarchy of two types, or occasionally of three, differing in at least some respects from those of all other observers, both in name and definition. The reason for this seems to be that the isolation of mental types has not sufficiently been made a matter of experimental investigation; and the observations made, usually under somewhat casual conditions, have not always been subjected to a sufficiently rigorous analysis. When this is done, it is found that, underlying most of these pairs of contrasted qualities, there does seem to be a real and very fundamental difference between one person's cognitive equipment and that of another. The matter is referred to, in greater detail, later.*

* Cf. chap. 10.

3. ANARCHIC VIEWS

Opposed to both the monarchic and the oligarchic doctrines is that which holds all human talents to be essentially independent of each other; so that, if a man excels at mastering, say, the French and Russian languages, that double excellence is fortuitous. It is not due to his being "intelligent", and so succeeding at two tasks, each of which requires a considerable degree of "intelligence". Nor is it due to his having a well-developed linguistic faculty. It is said to be due to a mere accident, in that he happens to be unusually good at each of two quite unrelated mental activities. Such a view has, at any rate, the merit of simplicity. Unfortunately, it seems to have the defect of not fitting the facts. As we shall see shortly, it is just in this realm of ability, if anywhere at all, where it is true to say that, "whosoever hath, to him shall be given" (5). Common observation, as well as elaborate experimentation, makes it impossible to resist the conclusion that human talents are not distributed in a haphazard way. There definitely are such things as brilliance and stupidity, in the general senses of these words; and, consequently, the man who excels at A is, *ipso facto*, more likely to succeed at B and C as well, than is the man who fails at A.

4. CONCLUSION

After reading so far, it may be wondered what sort of a study psychology must be, if mutually exclusive and even contradictory opinions can be held about the same topic by different, but equally eminent, authorities. There are two points worth consideration in connection with this.

(1) It will be seen in the following pages that, after all, there is some truth in each of the four views which have been discussed so far. That brings us to the second point.

(2) We shall find it not wholly surprising that the truth in their own particular views should, in the past, have blinded psychologists to the truths in other views. Until quite recently, the highly technical methods by which the problems of ability are now unravelled had not been invented. It is hardly an exaggeration to say that, until 1904, armchair speculation was the method most in vogue in the study of ability. It is true, of course, that experimental investigations had been made before then; but the interpretation of the results obtained was, in the main, a matter of the individual insight and personal preconceptions of the experimenter. In 1904, Spearman published the original statement (6) of the *two factors* theory, which we are now to study, and indicated the principal lines at present known along which knowledge of the nature of human talent can be advanced.

5. SUMMARY, AND ALTERNATIVE NOMENCLATURE

By way of summarizing what has been said in this chapter, the following alternative terms may be introduced (7). Theories of ability may be regarded as *uni-focal* (monarchic) when such a single trait as that of " intelligence " is held to be the determining factor in all cognitive performance; *multi-focal* (oligarchic), when a number of discrete " powers ", " faculties ", or " types ", are held to perform the same function (8); and *non-focal* (anarchic), when abilities are held to be without any necessary inter-relationships whatever. In brief, the determinants of ability have been thought of as being focussed in one trait, and in several; and also as being completely diffused and unfocussed.

REFERENCES

(1) Some of the more popular definitions of " intelligence " are well discussed by Rex Knight in *Intelligence and Intelligence Tests* (chap. 3).

(2) AM, p. 32.

(3) *Psychological Types.*

(4) *Temperament Tests*, BJP, January 1933 and July 1933.

(5) *Luke*, viii, xviii.

(6) " The Proof and Measurement of Association between Two Things ", *American Journal of Psychology*, vol. 15 (1904).

(7) Cf. Charles Fox; *Educational Psychology* (chap. 11).

(8) One objection to this nomenclature is, of course, that most of the doctrines of types could better be termed *bi-focal* than *multi-focal*; and confusion might therefore arise between them and the two factors theory. The latter, however, could also be regarded as *uni-focal*; and still further confusion might thus arise.

CHAPTER FOUR

THE TWO FACTORS THEORY

1. The Necessity for Experiment.
2. The Outcome of Experiment.
3. The Necessity for Mathematical Treatment.
4. The Statistician's Inevitable Conclusion.
5. The Observed "Factors".
6. Nomenclature: *g* and *s*.
7. Development.
8. Apparent Exceptions.
   (*A*) Habitual activities.
   (*B*) Innate activities.
   (*C*) *S*-"overlap".
9. Three Anticipations.
   (*A*) The variability of the *g* : *s* ratio.
   (*B*) Individual differences in *g*
   (*C*) Haphazard distribution of a person's *s*'s
10. The Factor and Other Theories.
   (*A*) *G*, and the monarchic doctrines.
   (*B*) *S*'s, and the anarchic view.
   (*C*) The factor theory *eclectic*.

1. THE NECESSITY FOR EXPERIMENT

Now it is clear, on the face of it, that there is only one way of deciding which, if any, of these views of ability is true. This is a problem which can be settled only on a basis of experiment. Armchair speculation has developed mutually incompatible answers to the same question; and it is unlikely that further armchair speculation will do much either to reconcile these answers with each other, or to choose between them. The only method which promises any finality of decision is to get together as many different people as possible, to test them for as many different abilities as possible, to compare the results, and to base one's views of ability upon the outcome.

2. THE OUTCOME OF EXPERIMENT

But, besides the obvious difficulty of devising tests and of getting people to submit to them, both of which have been overcome, there is another difficulty, even more formidable. If we test each of a hundred or of a thousand different people for each of twenty or of fifty different abilities, all that we shall get for our pains will be a very considerable mass of figures, representing their scores, or their order of merit at each task. We shall know, for example, that so-and-so obtained 35 marks out of 80 for remembering names; took, on the average, ·07 seconds to press an electric switch when he suddenly heard a bell ring; was 87th out of 320 testees at adding up figures; was guilty of 7 mistakes in making 48 judgments of musical pitch; and so on.

3. THE NECESSITY FOR MATHEMATICAL TREATMENT

But numerical data such as these are clearly matter for the mathematician, and not for the psychologist as such. The mass of figures must surely conceal the answers to some of the psychologist's problems concerning diversity of talent; but the task of making these figures yield the secrets of their own causation belongs not to psychology but to a special branch of mathematics, namely, statistics. It is the special province of the statistician to discern within an apparent chaos of numerical data any underlying principles of arrangement and interdependence which they may conceal.

4. THE STATISTICIAN'S INEVITABLE CONCLUSION

The actual statistical theorems which have been developed to deal with the problems presented by test-data are extremely complex and technical; but a simple exposition of their outlines is attempted in Appendix 1, to which the

reader is here referred. For the present, it must suffice to say two things.

(1) Thousands of persons of both sexes, young and old, sane and insane, in most parts of the world, have been subjected to tests covering hundreds of different cognitive activities.

(2) The results of this vast labour, when analysed by the appropriate statistical methods, point to one definite conclusion. This is that every distinct human talent, from the simplest to the most complex, from tying a bootlace to composing an opera, may be thought of as involving two very different constituents. One of these is the same for all abilities; while the other constituent is specific to the particular talent in question.

5. THE OBSERVED "FACTORS"

The position is simply this. When the statistician analyses a mass of actual test-data, he is forced to the conclusion that the figures before him are only explicable, could only in reason be taken to have happened in the way they did, if each of the abilities tested had these two constituents, or, as it is usually put, was a product of two such *factors* as these.

So far, psychology has hardly entered in, only mathematics; and, in consequence, two things follow.

(1) We can say that these factors are *observed* factors, they are not merely postulates.

(2) We can add that the validity of this two factors theory of ability stands or falls solely by the validity or invalidity of the statistical theorems and deductions involved.

It is well worth emphasizing that it is the mathematician, not the psychologist, who has been speaking so far; and who says that if the psychologist actually tests people for remembering names, and speed of muscular reaction, and

adding up figures, and judging pitches, and so on, the *results* lead to the conclusion that each one of these abilities depends on two factors.

6. NOMENCLATURE: *g* AND *s*

One of these, usually called *g*, or the *general* factor, is common to all abilities; and the other, called the *s*, or *specific* factor, is different for every distinct ability. We may say, then, that

remembering names depends on *g* and s_m,
reaction time depends on *g* and s_r,
adding figures depends on *g* and s_a,
judging pitch depends on *g* and s_p, and some other cognitive performance depends on *g* and s_x.

Throughout all these examples, and throughout all the thousands of others that might have been taken, *g* is the same. But s_m, s_r, s_a, s_p and s_x differ from each other and from all the thousands of other *s*'s that would have been involved, had we tested for other abilities in sufficient number.*

7. DEVELOPMENT

G, then, is a mathematically demonstrated general factor in ability in the sense that, whatever its ultimate psychological nature may be, it enters into every cognitive activity which a man or a woman, a boy or a girl, can undertake. In tying the bootlace, as in composing the opera; in filling a fountain-pen, as in writing a cheque with it when filled; *g* is involved.

But in addition to this one universal factor which affects every cognitive ability, the statistician also discovers a vast

* This statement receives qualification in § 8 (*c*), p. 29; and in ch. 6.

company of other factors, each specific to a single activity; so that the specific factor (whatever its ultimate psychological nature may be) in tying the lace, differs from that (whatever it may be) in filling the pen, and both differ from that involved in writing the cheque, or in composing the opera, or in performing any other distinct task whatsoever.

8. APPARENT EXCEPTIONS

There seem to be three exceptions to these generalizations. Two of them, both concerned with g, can be dismissed quite briefly now. The third, concerned with the s's, will just be mentioned here, and discussed fully in Chapter 6.

(A) Habitual activities. It seems that actions which are wholly habitual do not demand g. If you interrogate me with the words, "*Eight sevens ?*", I shall reply, "*Fifty-six*", purely as the result of a habit ingrained years ago, and g will hardly be involved. But if you were to put the same question to a child of eight, he would certainly utilize his g in making the same reply, for one's "tables" are hardly pure habits at that age.

(B) Innate activities. Purely innate actions, such as sneezing and scratching, do not seem to demand g. But it is clear that such pursuits as these, for which we are fully equipped without having to go through the pains of learning, can scarcely be dignified by the term "ability" at all; and, in consequence, hardly come within the scope of our discussion.

(C) *S*-"overlap". Activities which in one respect or another resemble each other very closely indeed, usually have an element of their s's in common. For example, if we say that Latin translation depends on g and s_T, and Latin grammar on g and s_G, then we shall find that both s_T and s_G are complex, and that they contain a common element,

much as each of the colours orange and green has yellow as a constituent.

These cases of non-distinct abilities which display a partial identity of their specific factors are of considerable importance in practice as well as theory. They are usually spoken of as exhibiting *s-overlap*, and Chapter 6 is devoted wholly to them.

9. THREE ANTICIPATIONS

Before passing from mathematics to psychology, three further things are worth touching on briefly, though each will have to be treated systematically and in greater detail later on.

(A) The variability of the *g* : *s* ratio. It appears from the statistical treatment of test data that abilities vary in the relative importance of the general and specific factors. In some, *g* is much more important than the *s* ; in others the *s* counts for far more than *g*. Spearman, discussing the fact that this ratio can be measured, says it was found that, " at one extreme lay the talent for classics, where the ratio of the influence of *g* to that of *s* was rated to be as much as 15 to 1. At the other extreme, was the talent for music, where the ratio was only 1 to 4 " (1).

But a warning is necessary here. The statement just made expresses an important general tendency, but no more. In order to assess the relative importance of *g* to *s* in any particular ability, a group of persons must be tested for it ; and the *g* : s ratio can be calculated for the group. Let us suppose that, in a particular group, *g* and *s* are found on the whole to be of equal importance for success at a certain activity. It does not therefore follow that the ratio $g : s = 1 : 1$, holds for every single member of the group. For example, of two people who make identical scores, one may rely on *g* rather

than on the *s*; and another on the *s* rather than on *g*.* Such a situation frequently occurs, in a crude and obvious form, in musical festivals; two competitors gaining the same marks in, say, the solo pianoforte class. But, whereas one scores heavily for *interpretation* but loses on *technique*, the other, with less *g* but better developed *s*'s, loses on *interpretation* and recovers on *technique*. It must be added, however, first, that experimentation into the magnitudes of *g* : *s* ratios has not yet progressed very far; and, secondly, that it seems *a priori* unlikely that, for any particular ability, individual differences in *g* : *s* ratios are of very great practical importance. The chances of a person succeeding at classical studies are very slight indeed, unless he unmistakably possesses well above the average amount of *g*. But this brings us to the topic of the next paragraph.

(B) Individual differences in *g*. It is an extremely important fact that *g* varies quantitatively from person to person, some having far more of this general constituent of cognitive talent than others.†

(C) Haphazard distribution of a person's *s*'s. It is to be added that the *s*'s tend to have little interrelation among themselves, and that in any given person they do, in fact, vary in effectiveness in a haphazard and highly chaotic way.

10. THE FACTOR AND OTHER THEORIES

(A) *G*, and the monarchic doctrines. The relevance of *g* to the monarchic theories of ability is sufficiently obvious. In those views " intelligence " was held to be the sovereign power of the mind, varying in amount from person to person, being involved to some extent in every conceivable cognitive

* Cf. p. 231 *et seq.*

† The manner in which *g* is distributed throughout the total population is shown in Fig. 43, p. 273.

undertaking and practically settling one's success at each. Such a doctrine clearly has much to commend it as, at least, a partial view of ability. *G* definitely is such a universal factor as "intelligence" is commonly held to be; and to that extent the monarchic view may claim mathematical sanction.

(B) *S*'s and the anarchic view. Similarly the *s*'s are clearly relevant to the anarchic doctrine, for that postulated much the same sort of multitudinous independent entities as the statistician finds in the specific factors of ability.

(C) The factor theory *eclectic*. It seems that both the anarchic and monarchic doctrines are right in what they stress, but that each is wrong in what it ignores. Each is right as far as it goes; neither goes far enough by itself; but, taken together, they do between them account for most of the observed facts of the distribution and variety of human talent. We shall see later that there is some validity as well in each of the two sorts of oligarchic view, and the two factors theory takes account of these truths also.* In this sense, it may fairly be described as *eclectic*; that is, as including the valid elements contained in other views.

REFERENCE

(1) AM, p. 75.

* See chap. 6, § 7, for *faculties*; and chap. 10, § 5, for *types*.

CHAPTER FIVE

THE FACTORS, *G* AND *S*.

A: THE GENERAL FACTOR, *G*

1. The Universality of *g*.
2. *G*, and General Ability
3. The Nature of *g*.
   - (*A*) Brain activity and consciousness.
   - (*B*) Thyroxine.
   - (*C*) A Possible Inference.
   - (*D*) Brain cells.
   - (*E*) Summary.
4. *G*, Inherited and Ineducable.

B: THE SPECIFIC FACTORS, OR *S*'S

5. The Neural Bases of the *s*'s.
6. *S*'s of a "Low Level"
   - (*A*) Receptor equipment.
   - (*B*) Effector equipment.
   - (*C*) Connector neurones.
7. *S*'s of a "High Level".

A: THE GENERAL FACTOR, G

1. THE UNIVERSALITY OF *g*

The presence of a certain amount of *g* is, as we have said (page 28 *et sqq.*), necessary for success in every cognitive activity which is not so purely habitual or innate as to proceed unconsciously; and the amount of *g* a man has at his disposal partly determines his success or failure at each. In learning a foreign language, or for that matter his own; in checking the week's newspaper account; in criticizing the play at a football match; in dodging the traffic when crossing a street; in listening to a piece of music; in driving a car; and in cutting a plank of wood, a yard of cloth, or a pound of steak; in all such abilities as these, *g* plays a part.

2. *G*, AND GENERAL ABILITY

It follows, therefore, that the presence of a high degree of *g* in a person constitutes a tendency to all-round mental ability, to success at every cognitive task undertaken. The converse is also true; deficiency in *g* makes for stupidity and a capacity for consistent failure throughout the realm of cognition. This, in extreme instances, may amount to complete idiocy.

3. THE NATURE OF *g*

This throws some light on the possible nature of *g*.

(A) Brain activity and consciousness. Putting aside all metaphysical and methodological presuppositions concerning the nature of the relation between neural and mental processes, it remains a fact that consciousness and the brain are intimately interrelated. In particular it is worth noting that in the absence of an adequate supply of blood the brain ceases to function, and we become unconscious. The same is true if the blood supplied to the brain is notably deficient in oxygen or glucose, or is charged excessively with toxic products as a result of some disease.

(B) Thyroxine. But the blood contains many things besides oxygen and glucose, and one of them seems especially important in any discussion of human ability. This is thyroxine, a substance of which minute quantities are secreted into the blood by the thyroid gland situated in the neck. Children in whom this secretion is congenitally inadequate constitute a definite type of mental deficient, and are called *cretins*. On the cognitive side, they can perform only the simplest processes, are sluggish and backward, and remain permanently infantile in their behaviour. In short they exhibit in extreme form the symptoms associated with poverty of *g*. This condition can, however, be remedied

either by hypodermic injections of thyroxine ; or by eating the actual gland, taken from sheep and dried. Either treatment must be maintained throughout life, otherwise the patient will speedily relapse into his former cretinism.

(C) A possible inference. The conclusion to be drawn from these two lines of evidence is not, perhaps, very definite. On the one hand, when the blood supply to the brain is reduced or is deficient in certain constituents, cognitive processes cease more or less abruptly, and unconsciousness supervenes. On the other hand, one very special form of *g*-deficiency is due to lack of thyroxine, and can be counteracted by artificially introducing the missing secretion into the blood-stream. It may be said, then, that no cognitive processes are possible unless the brain is freely supplied with blood ; and that all of them are impaired and may be abolished if the blood is deficient in certain constituents. *G*, then, in the ultimate physiological analysis, may well be *in part* some complex function of the brain's blood supply.

(D) Brain cells. The words " in part " are necessary here, since, as we have implied, there are other forms of cognitive incapacity that can not be traced to deficiencies in the blood stream. The common supposition is that some at least of these non-cretinous varieties of general imbecility are due to defective cellular tissue within the brain itself.

(E) Summary. From the purely psychological point of view, the nature of *g* is quite definitely established, and will be expounded at length in due course.* Here we shall anticipate the more detailed discussion to say that it is concerned with the grasping of the relations which ideas bear to one another, and with the utilization of these relations in new contexts. For the present it will be sufficient to regard *g* merely as the factor which enters to greater or less extent

* Chap. 22, § 1, p. 183.

into all cognitive processes. Some people, those who most commonly earn for themselves such designations as "clever", "brainy", or "intelligent", possess more of it than others, whom we think of as relatively "dull", "stupid", or "unintelligent". Its existence has been established mathematically; and on the physiological side it seems to stand in a complex and imperfectly understood relationship to at least some of the contents of the blood stream; and, maybe, to some obscure quality of the brain cells as well.

4. *G*, INHERITED AND INEDUCABLE

This should prepare one for the prevalent view, now very cogently suggested by actual research, that *g* is inherited and ineducable. It does seem quite certain that such things as blood and glandular constitution, and the quality of the tissues of the brain, are legacies from our parents. The first two can only be modified to advantage by hypodermic or dietetic interference with the system; or in the opposite manner by disease. As for brain tissues, these cannot be improved in any way at all, although they may be impaired by mechanical injury, disease and toxins. Similarly, *g* seems to be inherited and to develop in a way which cannot be improved either voluntarily by the person concerned or, except in the one case of cretinous imbecility, by any external environmental influences which can be brought to bear upon him. On the other hand it may be impaired by any of those agents which bring about deterioration of brain tissue. As for children and adults who are said to have become more "intelligent" after psycho-therapeutic treatment, it can hardly be claimed that they then possess more *g* than they did before. Previously they failed to make full use of what they had, and the treatment has removed the inhibitory agency. But to release a thwarted power is very different

from creating new power, even though the superficial results may be the same.

All this is not to say that an adult cannot improve his efficiency in this or that particular cognitive task, even without the aid of therapeutic treatment. Such improvements are constantly occurring, and will be discussed in due course ; but they are in no wise due to quantitative improvements in *g*. Casual observation and careful investigation combine to show that no amount of training will add to the general cognitive factor in one's abilities. One has to be content with the legacy of " intelligence " which one's ancestors have passed on, seeking among the *s*'s for the means of self-betterment.

B : THE SPECIFIC FACTORS, OR S'S

5. THE NEURAL BASES OF THE *S*'S

Like *g*, the *s*'s, or specific factors of ability, have extremely complex origins ; but here knowledge is rather more definite. They seem to be wholly physiological, consisting largely of what are termed receptor (sensory) and effector (muscular) organs ; and receptor, connector and effector neurones, or nerve cells.

6. *S*'S OF A " LOW LEVEL ".

Consider, for example, the *s*'s involved in avoiding a rapidly approaching car when crossing a busy street. In such an activity the emphasis lies on purely physiological elements. The mental aspect, though definitely present, is much less pronounced than in, say, thinking out a problem in politics, or in recollecting the details of an almost forgotten happening. As such, it may be described from the psychological point of view as a relatively " low level " activity.

(A) Receptor equipment. In the first place the condition of the eyes is important. Let us suppose that you have spent the morning in a poorly-lit library, translating dreary acres of German printed in small Teutonic characters like these. Outside is brilliant sunshine, and a fall of snow. Your retinæ, and the eye muscles which normally secure rapid adjustment of focus, will be fatigued and relatively irresponsive; and the pupils themselves will have become dilated in order to compensate for the poor illumination in which you have been working. As a result, the brilliant light outside will seem excessive and dazzling, and will impair your entire vision; so that an approaching car will not be seen either as quickly or as clearly as is normal to you, because of the retinal and muscular fatigue. Thus your ability to avoid rapidly moving objects will have undergone a definite deterioration, which is in no degree traceable to any modification of the general factor of ability, but is due solely to a change in the factor specific to avoidance of such objects. Further, your efforts in the library will have done more than merely impair your eyes, the receptor organs of vision. They will also have impaired the receptor neurones, the nerve cells which link the retinas of the eyes to the appropriate portion of the brain.

(B) Effector equipment. Let us suppose, too, that your excessive zeal at translation has been necessitated by the fact that you spent the previous day, when you should have been in the library, in learning to skate. The muscles of your legs, the effector organs of avoidance, will still be fatigued, and consequently stiff and irresponsive; while it is probable, too, that the effector neurones, the nerve cells linking the muscles with the spinal cord, will also offer greater resistance than is usual to the passage of nervous impulses. The result is that you are less well equipped than

usually to come to a sudden stop, to put on a sudden spurt, or to retreat quickly.

(C) Connector neurones. But in seeing and avoiding a car other neurones are involved, besides those we have mentioned so far. These form a vastly complicated system of nerve cells connecting the receptors which end in the brain with the effectors which begin in the spinal cord. It is very improbable that even the most trying experiences in the library will have done much to impair their efficiency; but another example, that of learning to skate, will illustrate their importance as a functional part of an *s*. Acquiring the ability to skate demands *g* and the building up of a new *s*. It is certain that there are already many alternative connector paths linking the muscles of the legs to those parts of the brain to which neurones pass from the delicate organs of balance situated in the ears. During early life many such paths are formed, consolidated and multiplied by practice at walking, running, hopping, jumping, skipping and the like; but if, years later, we put on a pair of skates for the first time, none of these pre-existing connections is itself adapted to make the muscular adjustments necessary to maintain balance in the novel situations of skating. A new system of connections, adequate to the new postures and to the new sequences of muscular reactions, has to be built up.

It may be said, then, that the basis of the specific factors in ability seems to be physiological, consisting in the main merely of neurone systems and the receptor and effector organs they link. It will be seen later that the neurones have various properties—besides that of fatigue, which has been mentioned already—which affect their value as functional linkage systems, but the picture given of them so far is sufficient for the present.

7. *S*'S OF A "HIGH LEVEL"

It may, perhaps, be thought that the *s*'s underlying relatively simple activities, like skating and dodging cars, may well be accounted for in such neurological terms as these; but that when "high level" abilities—subtle and complicated ones—are concerned (for example, those involved in abstract thought processes, where the emphasis is removed from physiological to mental reactions) mechanisms of altogether another kind must be involved. That this is not so is illustrated by the personal case history of the late Dr. Saloz (1).

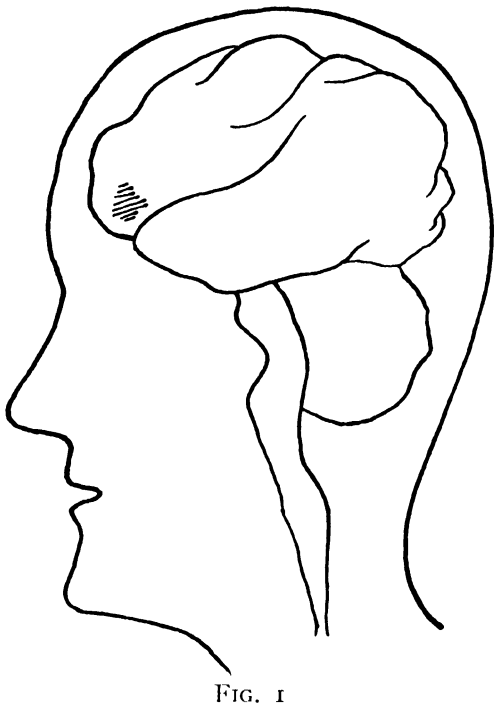

FIG. 1

By way of introduction it must be said that, in *right*-handed persons, destruction by disease of that portion of the *left*-hand side of the brain which has been shaded in Fig. 1, is accompanied by the loss of all linguistic powers. It is stated authoritatively that "of this region it is clear that the anterior part is concerned with expression, and the posterior part with reception" (2).

When about sixty years of age Dr. Saloz lost the powers of writing, of uttering all words except a few absolutely habitual ejaculations, and of recognizing even single letters of the

alphabet. During the next three years he successfully re-educated himself, starting as a child would with the very rudiments of language acquisition; and was finally able to write a complete account of his own case. Post-mortem examination showed that the portion of the brain previously referred to had completely atrophied, the deeper portions being particularly affected.

It is inevitable to infer that a man who, starting from zero at the age of sixty, could in three years master an entire spoken and written language, has a *g* but little impaired by his tragic physical handicap; and this is perhaps borne out by his own evidence that ideas were present to him, though at first it was impossible to give them verbal expression. Be that as it may, two facts are undoubted. First; those nerve cells in the brain which normally subserve language were, in Saloz's case, useless. Secondly; since the autopsy revealed that they had never recovered, despite the re-learning, it is evident that other nerve cells had assumed their functions. Using our present terminology, we may say that the original *s*'s of speech, writing and word recognition having atrophied, Dr. Saloz had built up fresh ones; and we may conclude that even in such subtle mental activities as these of language the specific factors are groups of actual nerve cells, chiefly in the brain. This is an extremely important conclusion which the reader should keep in mind when, in later chapters, *s*'s are referred to as being, for example, *informational*.*

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(1) *Archives de Psychologie*, 1919.
(2) *Handbook of Physiology*, p. 669, Haliburton and McDowell.

* Cf. p. 104.

CHAPTER SIX

S-OVERLAP

1. Recurrent Elements among the *s*'s.
2. The Detection of Overlap.
   - (*A*) Correlation due to *g*.
   - (*B*) Correlation due to *s*-overlap.
3. Summary.
4. Diagrams illustrating Overlap.
5. Overlap.
   - (*A*) Unimportant.
   - (*B*) Important.
     - i. Mechanical talents.
       - (*a*) In constructive abilities.
       - (*b*) In routine or manual activities.
     - ii. In social activities.
     - iii. In arithmetical abilities.
     - iv. In memorization.
     - v. In other activities.
6. So-called "Group" and "Broad" Factors.
7. Overlap and the "Faculties".

1. RECURRENT ELEMENTS AMONG THE *S*'S

It was said on page 29 that activities which in one respect or another resemble each other very closely indeed, usually have an element of their *s*'s in common; and the example of Latin grammar and Latin translation was quoted. Two further examples have been given incidentally. The first was that of translating German and seeing a moving car, in which the common element was the condition of the eyes; the second, that of learning to skate and avoiding the car after its approach has been seen, in which the common element was the condition of the legs. In the former example the two *s*'s share the same receptor organs and neurones, namely the eyes and the visual nerves; while in the latter

the *s*'s share the same effector organs and neurones. Now quite a number of other cases have been discovered in which the recurrence of certain elements in several *s*'s takes place in a much more subtle, elaborate and important way; and in all these cases of recurrence, simple or elaborate, it is usual to speak of the *s*'s as *overlapping* each other.

2. THE DETECTION OF OVERLAP

The method by which such recurrence or overlap can be detected with precision, and measured, is mathematical; and is accordingly described in Appendix 1 (§ B, 3). Here it is sufficient to remind the reader that the presence of a high degree of *g* in a person constitutes a tendency to all-round mental ability, to success at every cognitive task undertaken (page 34); and to add that, when abilities are actually tested and the results are treated statistically, it is found that certain talents are associated, or, to use the technical term, *correlated*, with each other more closely than they would be if *g* were the only factor common to them.*

(A) Correlation due to *g*. To revert to our first example, we should expect the boy who excels at Latin grammar to be above the average at Latin translation, if only because *g* is involved in both. His excellence at the grammar suggests *a posteriori* that he is probably more gifted with *g* than most boys. But algebra involves *g* also; so we should, *a priori*, be justified in expecting that this boy would also be above the average at algebra. In actual fact it is much more probable than not that both expectations would be realized; but the chances that he will excel at translation are found, in practice, to be even greater than the chances that he will excel at algebra.

* The technical significance of the term "correlation" is discussed in Appendix 1, § 1, p. 276 *et sqq.*

(B) Correlation due to *s*-overlap. The reason for this is quite obvious. Besides demanding *g*, Latin grammar and translation have many other features in common which neither shares with algebra. In addition to a considerable identity of subject matter there is also likely to be a subtler influence due to the fact that the same master will probably have dealt with the two branches of Latin, while a different master, employing a different method and approach, will have been teaching the algebra. When the problem is approached from the physiological side it seems reasonable to suppose that mental activity in subjects so closely allied as the first two involves to a large extent activity of the same nerve cells in the brain, whereas algebra calls upon at least some quite different neurones.

3. SUMMARY

It is found, then, statistically, that talent for Latin grammar is associated or correlated, in the first place, with talent for Latin translation, and, in the second place, with talent for algebra; and these two correlations are traceable to the fact that *g* is involved in all three activities. But the first of these two correlations is found to be much more marked than the second, for the *s* involved in grammar is in part identical with the *s* involved in translation; whereas it is distinct from the *s* involved in algebra, only *g* being common to these two studies.

4. DIAGRAMS ILLUSTRATING OVERLAP

Fig. 2 serves to illustrate this, each circle representing the particular talent shown, and each being divided into blank and shaded portions to represent roughly the relative importance of *g* to *s* in that particular ability. When, however, s_T and s_G, the specific factors in translation and

grammar, respectively, are examined, it is found that each is complex, s_T being divisible into s_t and s_c, and s_G into

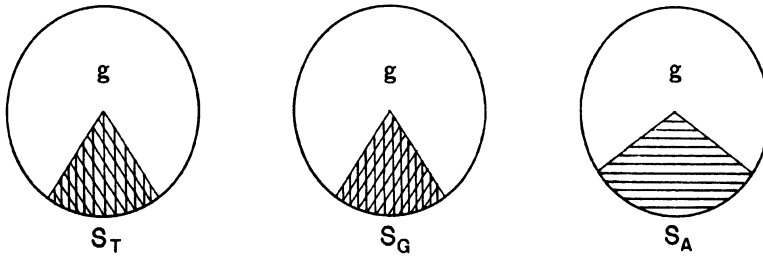

FIG. 2

s_g and s_c ; s_c being common to each ability, and representing the overlap of, or identity between, the specific factors s_T and s_G. This is suggested in Fig. 3, where s_c is shaded in

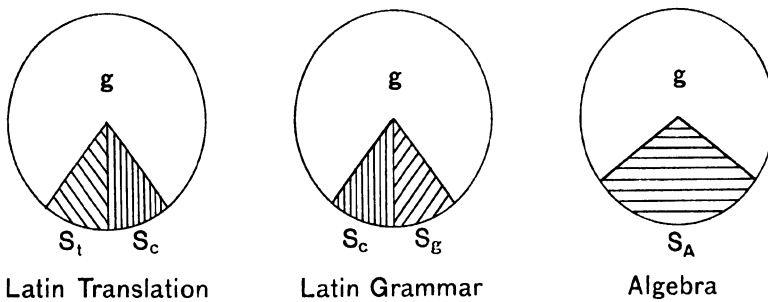

FIG. 3

the same way in each circle where it appears. The boy, then, who excels at translation, does so because he is well equipped with g, s_t and s_c ; and, since grammar also demands g and s_c, he is clearly very well equipped indeed for success here also.

In grammar and translation there are, then, two common factors, g and s_c ; and hence success at one is very intimately correlated indeed with success at the other. Between grammar and algebra there is but one common factor (g), though a very important one ; and hence these two talents are correlated, but not with the degree of intimacy shown

by grammar and translation. The same is also true of translation and algebra.

5. OVERLAP

(A) Unimportant. It must now be inquired how often *s*'s are found in practice to display overlap, or partial identity of constitution. As we have said already, if any two activities are very similar indeed, some part of each of the two *s*'s appears always to recur in the other. A simple laboratory example of this might consist in crossing out certain letters from a page of print, first, one at a time, and then two at a time. The subject has first to cross out, say, all the *e*'s, and then all the *m*'s and *r*'s. Now although *g* enters into neither ability to any marked extent, it would be found that they were none the less associated very closely indeed, for the two *s*'s overlap to a very considerable extent. But clearly this common element is of no great scope, and of little practical importance except, perhaps, to proof readers.

(B) Important. In the whole realm of ability some five or six examples of *s*-overlap of undoubted importance are known to-day; and rather more than half a dozen others at whose importance it is at present hardly safe to guess. As research continues there is no doubt that some of these will be found to deserve more detailed treatment than they receive here; and, equally without doubt, still further examples will be discovered. The really important ones known so far, are dealt with in the following paragraphs.

(*I*) *MECHANICAL TALENTS.* When many very varied mechanical performances are tested in a large number of people, at least two examples of *s*-overlap are found.

(*a*) *In constructive abilities.* In the first place, activities which demand a real insight into the nature of mechanical processes are found to be correlated among themselves more

closely than they would be if their *s*'s were wholly independent, and *g* consequently their only common factor. That is to say, a person who tends to grasp readily the functional interrelations of the parts in one sort of machine is found in practice to be the person who will readily grasp similar relations in other sorts. To take a concrete example; the testee who, given the separate parts of some *unfamiliar* mechanism, say, an electric lamp holder or the hub of a bicycle, can assemble them accurately and quickly, also tends to be successful at solving such test problems as the following:

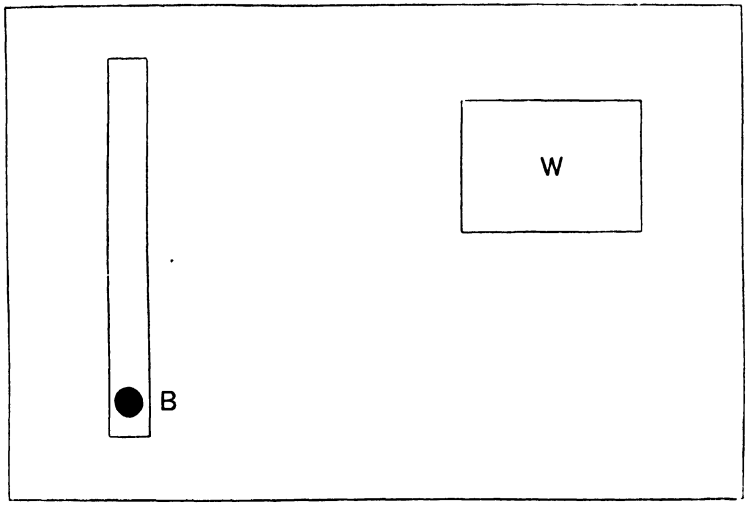

FIG. 4

A wooden model, like that in Fig. 4, is shown to the testee, whose attention is drawn verbally and by demonstration to the following points:

> When the knob *B* is in its present position, the window *W* is closed by a shutter behind it. As *B* is pushed up the slot, *W* opens and remains so until *B* reaches the top of its slot, when *W* again closes. As *B* travels down the slot, *W* opens and remains so until *B* reaches the bottom, when *W* again closes.

When B is at the bottom or top, W is open; for all other positions of B, W is shut.

The model works in any position.

The testee has then to draw a mechanism which would account for the observed functional relationship between B and W. Ability to solve these three problems can be analysed into factors which can be called

g and s_L for the lamp holder,
g and s_H for the hub, and
g and s_M for the model.

But s_L, s_H and s_M are in turn analysable respectively into

$s_l + s_c$,
$s_h + s_c$, and
$s_m + s_c$,

s_c being the same common element in s_L, s_H and s_M.

A very careful and elaborate research by Dr. J. W. Cox has elucidated the nature of s_c, the overlap between the s's involved in what may be termed constructive mechanical talents (1). In assembling the components of an unfamiliar mechanism so that they function together successfully, and in the invention of a mechanism which will account for a whole sequence of events—of which only the first and last stages have been seen, the common element appears from Cox's analysis to consist at rock bottom of grasping the changing spacial relations between the different moving parts of the mechanism, and hence on being able to think of the whole as a single unit in which all the parts are interdependent. The machine in function then becomes a changing pattern of mutually related parts, one phase of the pattern having evolved naturally from the previous one, and evolving inevitably into the next. Roughly speaking this is equivalent to the power of grasping on the mechanical

level the relations of cause to effect and of effect to cause; the presence of such a power tending to give insight into the nature of all mechanical operations, even when the apparatus is unfamiliar or merely imagined; and its absence tending to leave all mechanical things and processes mysterious and incomprehensible. It has nothing to do with mere manual or digital dexterity, and may be possessed by the clumsiest of people.

(*b*) *In routine or manual activities.* On the other hand some simpler mechanical activities exhibit another example of *s*-overlap. Such are activities in which the main requirement is manual and digital skill as involved in assembling and stripping an electric lamp holder *after* the methods of doing so have been thoroughly grasped, or in putting large rings on a rod, or in threading beads. The common element in the various *s*'s involved appears to consist in the more or less complex finger movements which each of these activities, particularly the first, demands (*2*).

(*II*) *IN SOCIAL ACTIVITIES* (*3*). Within the realm of human intercourse described nowadays by Americans as that of "social contacts" there seems also to be overlap. Ability to solve one difficult problem of personal conduct is more closely allied with ability to solve other such problems than it would be if *g* were the only factor common to them.

(*III*) *IN ARITHMETICAL ABILITIES* (*4*). Another important case of *s*-overlap is that exhibited by arithmetical operations of all kinds. The talents for mental as well as written calculations; for the fundamental rules of addition, subtraction, division and multiplication; for longer but still straightforward computations; and for even more complex "problems", are correlated more closely than they would be if *g* were their only common factor.

(*IV*) *IN MEMORIZATION.* Slight overlap has been found to exist throughout the entire field of memory, the tendency to remember any one type of material well being more closely correlated with the tendency to remember all other types well than it would be if whatever *g* such processes require were the only factor common to them (5). In addition, a more pronounced example of overlap has been noted which is restricted in its scope to verbal memories alone (6); and there is also evidence of further overlap among memories of non-verbal symbols (7). Again, overlap of some magnitude has been shown to exist throughout the range of sensory memories (5); and within this same range there is evidence of smaller overlaps between memories of (*a*) things seen and heard; (*b*) things seen and handled, and (*c*) things handled, tasted and smelled.*

(*V*) *IN OTHER ACTIVITIES.* The following classes of activity have also been found to show some overlap:

Linguistic (8).
Logical (9).
Musical (10).
Rapidity of reaction to different stimuli (11).
Imagery (12).

6. SO-CALLED "GROUP" AND "BROAD" FACTORS

It may be noted in passing that there is a considerable tendency to-day to refer to these examples of *s*-overlap as the "group factors" of ability; or sometimes even as the "broad factors" of ability. Thus your success at being

* These last three results emerged from a study made by Dr. Elsa Walters as a preliminary to a larger investigation which has not yet been completed. Unlike the other results which have been quoted, these are so far unpublished. Dr. Walters has, therefore, been good enough to make a résumé of her research, and this is to be found in Appendix 4. The present writer wishes to record his indebtedness to Dr. Walters both for preparing this résumé and for permission to make use of it here.

really charming at the bridge table to the partner who has trumped your ace is said to depend on your *g*, your *s* for this sort of thing, and on your *social "group" or "broad" factor.* The only objections to this are :

(1) that it suggests the existence of a third *kind* of factor, over and above *g* and *s*, and existing independently of both ; and consequently,

(2) that we can, as it were, bring to the solution of social, arithmetical and mechanical problems, and to a few other sorts, three different kinds of factor—general, specific and group (or broad) ; while to other activities, say, to playing chess, we can bring only two—general and specific.

But this is to assign an independence of existence, which they hardly seem to possess, to what are, after all, merely fractions of certain *s*'s. On the whole it would seem more accurate to avoid the terms "group" and "broad" factor altogether ; and to think rather of an *s* as being necessarily very complex, and containing sometimes an element found in other *s*'s as well.

If, however, these terms are retained, the following seems to the present writer to be their only permissible usage.

The term "broad factor" should be restricted to such marked and extensive examples of overlap as those discussed in § 5, *and should only be used when considering ability as a whole.*

The term "group factor" should only be used for any case of overlap which is found to occur *within a limited and specified range of abilities* ; but it may be used whether the overlap is one of the types enumerated in § 5 or of much smaller scope.

Thus, from the point of view of ability *as a whole*, linguistic

and arithmetical aptitudes may both be regarded as *broad* factors. But, on the other hand, if tests of

(1) finding synonyms,
(2) multiplication,
and (3) subtraction,

are *alone* being considered, linguistic aptitude enters into the battery of tests only as a *specific* factor [in test (1)], and arithmetical aptitude enters into the battery only as a *group* factor [in tests (2) and (3)]. Neither can, in such a small range of activities, be thought of appropriately as a broad factor.

The fundamental objection to the two terms discussed here is that they obscure the basic two-fold nature of ability. Any given talent demands *g*, which it shares with every other similar or dissimilar talent; and also an *s*, which may or may not be partially shared by a limited number of similar talents. This topic is resumed at the end of the next chapter.

7. OVERLAP AND THE "FACULTIES"

It was said on page 32 that we should find some truth to reside in the "faculty" view of ability; and the facts of overlap provide the justification for this assertion. Let us consider as an example the man who excels at doing odd mechanical jobs. He has taught himself, shall we say, to repair among other things a clock, a typewriter, and a sewing-machine. It would be very surprising indeed if he were to take his car to the garage for overhaul and decarbonization; or to send for a professional expert if a key broke in the garage lock and made it unusable. *S*-overlap seems to exist throughout the range of activities of this kind; and it would not be altogether inept to speak of such a man as we have described as having a "mechanical

faculty". But such "faculties", as we have seen, are few in number; and they by no means correspond to any traditional list.

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(9) AM, pp. 225-226. Peterson, PR, 15.

(10) AM, p. 242. Seashore and Mount, PM, 25. T. H. Pear, BJP, 1911.

(11) AM, pp. 235-236.

(12) AM, p. 238.

CHAPTER SEVEN

THE "ENERGY-ENGINE" HYPOTHESIS: I

1. Fact and Theory.
2. *G* and *S*: Energy and Engine.
3. Overlap.

1. FACT AND THEORY

In accordance with our intention, expressed in the Introduction (page 2), to distinguish as clearly as possible between the observed facts of ability on the one hand and hypotheses about ability on the other, we have so far considered only the facts. Hardly anything has been said up to the present which cannot be verified by anyone who has the opportunity of acquiring the necessary experimental technique and statistical knowledge, and avails himself of it. The only exceptions to this would seem to be in connection with some of the statements which have been made about the physiological aspects, some of which are in the nature of inferences rather than of observations. But the existence of *g* and of a multitude of *s*'s is very definitely established, even should the apparent connections of the former with the blood and the brain cells, and of the latter with the nervous system, prove illusory. Now that we have reviewed the established facts, theorizing about them is permissible; provided we remember that we are only theorizing.

2. *G* AND *S*, ENERGY AND ENGINE

The most acceptable view seems to be that *g* behaves *as if* it were a sort of undifferentiated cognitive energy, and the *s*'s *as if* they were a multitude of different cognitive mechanisms or "engines", any of which *g* can activate (1).

The analogy of electrical energy is frequently used. The same supply of electricity could be employed either to ring a bell, work a motor, heat a filament, provide a shock, fire a charge of explosive, radiate a "wireless" message, or plate a piece of metal with nickel or silver, merely according to the sort of apparatus to which it was connected. Similarly *g*, or cognitive energy, will enable you to work out a sum, or translate a passage of French, or play chess, or write a letter, or cross a street without getting run over; it all depends upon which specific engines, or *s*'s, it happens to be activating. But it must be remembered that all this is just a convenient analogy. We are only safe in saying that *g* does behave *as if* it were such an energy, and that the *s*'s behave *as if* they were alternative mechanisms which only become active in co-operation with *g*. Moreover it will be remembered that exceptions to this rule have to be made on behalf of innate and habitual acts, which do not demand *g*.*

All this certainly fits in with the other facts we have seen so far. People vary in the amount of *g* at their disposal; that is, some, the "intelligent" ones, have more cognitive energy than those who are "duller". So, if you are one of the former, your *s*-mechanisms have a more plentiful supply and are enabled to work to fuller capacity than the *s*'s of people with less *g*-energy than you. In addition, in any given person, some *s*-mechanisms are more efficient than others. Lastly, in some cognitive activities, like music, the mechanism is more important than the energy; while in others, like classics, the reverse is true. This last topic is of tremendous practical as well as theoretical importance, for it lies at the root of the problem of the actual measurement of a person's *g*. It is discussed more fully later.†

* Cf., for example, pp. 29 and 71. † Chap. 22, p. 183 *et sqq.*

3. OVERLAP

The facts of *s*-overlap are quite readily "explained" by this energy-engine hypothesis. What we have termed a "recurrent element" in two or more specific factors is like a piece of wire that can be used equally well in this, that, or the other electric circuit; or, better, like an endless band that is used to connect a lathe, a drilling machine, an emery wheel and a circular saw to their common source of power. If I take a piece of metal to the workshop to be cut and drilled, first one machine and then another will be linked to the power supply; and a certain endless band may form a part of both linkage systems. But from the point of view of the activities of cutting and drilling it can hardly be said that this particular band has any functional significance apart from the rest of one complete mechanism or the other. If we regard the saw and drill, together with the apparatus that links them to their common source of energy, as the specific factors in cutting and piercing holes, it seems rather odd to isolate the band, a single element in the two mechanisms, and to call it, say, a "transmission group (or broad) factor", as though it were an entity of a third additional kind. The so-called "group factors" and "broad factors" do not supplement the general and specific ones—they are merely recurrent portions of the latter kind.

REFERENCE

(1) Cf., Spearman, *A Measure of "Intelligence" for Use in Schools*, p. 1.

PART THREE

PERSONAL VARIATIONS IN ABILITY

THE PROBLEM

We come now to the second of the two obvious and important problems of ability. This is not concerned with any differences between one person's talents and those of another, but with the fact that everyone of us exhibits from day to day, and even from hour to hour, variations in capacity. Sometimes we are "on form"; and then we have our "off" periods. To-day I played chess and won. Yesterday, against the same opponent, and in circumstances that seemed to all intents and purposes identical, I lost. This afternoon in typing these lines, I have made mistakes on every page. This morning I scarcely made an error at all.

Continuing with the terminology that has served us so far, we can say that g *and the appropriate* s *between them determine our* maximum *efficiency at any given task. But in daily life our actual cognitive performances often fall far short of what in ideal conditions our* g-s *equipment would enable us to obtain.* WE HAVE NOW TO EXAMINE THE REASONS FOR THIS DISCREPANCY BETWEEN POSSIBILITY AND PERFORMANCE; BETWEEN WHAT WE MIGHT HAVE DONE, AND WHAT WE ACTUALLY DID.

There are several agents which militate against maximally successful cognition; and in any every-day situation a number of them may combine to hamper us and impair efficiency. For the purpose of clear exposition these factors of failure are treated in isolation from each other. But the reader should keep

in mind the fact that, in ordinary cognitive life, contributions to human fallibility are made from many sources operating together. Hence in the pages that follow, if failure in some process is put down, say, to fatigue, the probability that other causes would normally have been involved as well must constantly be remembered.

In accordance with the method adopted so far, the facts which we are to discuss will be presented as " laws " ; in this case the " quantitative *laws " of cognition. From the functional, as opposed to the merely descriptive, point of view, these factors of failure can best be described as the* quantitative " determinants " *of ability, a term which duly emphasizes their role as limiting, or determining, the efficiency of our* g-s *mechanisms. Theorization will follow description in its proper place.*

CHAPTER EIGHT

THE CONSTANCY OF COGNITIVE OUTPUT

1. The Distribution of Awareness.
2. Cognitive Competition.
   (*A*) Competition on the sensory level.
   (*B*) Competition at higher levels.
   (*C*) Competition among recollections.
3. Competition limited to the Sphere of *g*.
4. Affective Competition.
5. Conative and Volitional Competition.
6. Two Further Observations.
   (*A*) Span.
   (*B*) Automatic writing
7. Conclusion.

1. THE DISTRIBUTION OF AWARENESS

There is one phenomenon of cognition which demands some preliminary discussion before we can deal adequately with the main problem of this present chapter. For the moment we will limit the discusion to visual cognition. The first rough draft of these lines is being scribbled in a tent. Half an hour ago a heron alighted at the edge of the lake some forty yards away ; and althuogh at that moment I was looking at the paper before me, I was aware of his arrival. This suggests a simple experiment. I saw the heron while looking elsewhere ; how much can I see while looking steadily in front ? For the moment I fixate the spot where the heron alighted, and keeqing my eyes focussed there, I examine the entire content of visual cognition. It is surprisingly large ; but much the greater part is extremely faint. It extends on my left to the camp stool with the typewrter balanced on top, and on the right to my climbing boots which should not

be inside at all; a total angle little short of 180 degrees. Somewhat above the spot I am fixating I become aware of a patch in the tent cloth; and at a slightly bigger angle below there is the pencil and the hand with which I am holding it. In a vertical plane my field of awareness subtends an angel of, perhaps, some 100 or more degrees.

In short it seems that awareness is distributed in a rather uneven fashion over the field of momentary consciousness. There tends to be a focus of vivid cognition surounbed by a halo in which awareness becomes progressively fainter. Around its outer edge the halo itself merges graduatly into an area of which we are quite unconscious. The picture we see in a momenttary flash of cognition, in a single *augenblick*, is a vignette; it has none of the defined margins of an ordinary photograph. In this respect cognition resembles the spot-light on a stage rather than the footlights. It picks out, and illuminstes vividly, a single item in the centre of the total scene; surrounds this with a halo of half light; and leaves the remaiuder in darkness. It is this fact which explains, in part, why you have noticed only a few of the twelve errors in typography which have been introduced deliberately into this paragraph and the previous one. In reading a passage it is the meaning which occupies the focus of consciousness; individual letters tend to remain in the margin and to escape full cognition. How it comes about that a partly cognised *remaiuder* can convey the meaning of a fully cognised *remainder*, is another question which will be discussed in detail in its proper place.*

Similar conditions prevail in other fields of awareness than the visual. If I listen intently to the mountain stream nearby, the sounds of the lake, of the car on its other side, of the sheep and the multitude of birds, and of the trees and

* Pp. 73, 150 and 242.

tent in the wind, must remain in the background of my consciousness.

2. COGNITIVE COMPETITION

These facts of the distribution of awareness bring us at once to the chief topic of this chapter. There are many reasons for holding that, at any given moment, we can cognise so much and no more ; and that the amount cognised tends to remain about the same, however much it may vary in kind.

(A) Competition on the sensory level. In the realm of simple sensory perception we can, let us say, become acutely conscious that we are hungry. Perhaps we have toothache also ; but, if so, it is difficult to be aware of this so long as the realization of our hunger remains in consciousness. If the toothache is acute and obtrudes upon us, it usually does so by ousting the hunger for the time. Truly, consciousness of the two states may alternate with remarkable rapidity ; but to be aware of both at the same time requires a considerable and unnatural control over cognitions.* A simple experiment would be to watch something intently, say, a particular letter on this page ; and at the same time to listen to any continuous noise, for example, that made by the fire, or the faint hum of a wireless set when not actually tuned to a transmitter. Careful self-observation will show that it is just possible to be momentarily aware of the two experiences as separate but simultaneous entities, but that they tend either to interfere with each other very much, or else to fuse into a single experience within which neither is differentiated properly. In the case, which seems very rare and always fleeting, where the two experiences are cognised separately but simultaneously, careful introspection will

* Cf. chap. 13.

reveal that they are, as it were, seldom equally balanced. Usually one forms a sort of background to the other, the latter tending to be more vividly in awareness than its competitor; though, perhaps, not as vividly as it would be if competition were absent. In a moment the balance will have swung the other way, the experiences being reversed in point of vividness.

(B) Competition at higher levels. Another simple experiment illustrates the same process at a higher level, and is well worth the actual performance. First, write a copy of any previously unseen printed matter as rapidly as possible for half a minute. Secondly, perform mentally some simple but protracted sum, also for half a minute and as rapidly as possible.* Thirdly, try to perform the two operations simultaneously for the same length of time. It will be found that there is a serious loss of efficiency at both performances. Each interferes with the other, and it is almost impossible to perform them simultaneously at all. *G* has, as it were, to be switched rapidly from one *s* to the other and back again; it is only with the greatest difficulty that it can be shared, even for a moment, between the two *s*'s.

(C) Competition among recollections. Further obvious examples of the very limited amount that can be cognised at any given moment can be taken *ad lib* from the realm of recollection. Of all the myriad of personal experiences and items of information which the reader could recall, only one can occupy consciousness at a time. To think vividly of *Hastings* is to leave 1066 neglected on the margin of awareness; and if the spot-light of consciousness focusses clearly on 1066 for a moment, then it is the turn of *Hastings* to fade

* For example, start with any sum of money, and add mentally the various common coins (£1, 10s., 2s. 6d., 2s., 1s., 6d., 3d., 1d.) in order. Thus, £5 6s. 7d. becomes in turn: £6 6s. 7d., £6 16s. 7d., £6 19s. 1d., £7 1s. 1d., etc.

at once into the ring of half light which surrounds the glare of full cognition and separates it from the outer darkness of oblivion. Inseparable though these two ideas doubtless are to most of us, yet their association tends to be one of succession in consciousness rather than of simultaneity. One of them is all that we can cognise clearly at a time.

3. COMPETITION LIMITED TO THE SPHERE OF *g*.

It must be added, of course, that we are only speaking of activities in which *g* is involved. You can ride a bicycle along a straight and empty road, and rehearse the next day's lecture at the same time; but it is advisable to prepare the lecture on another occasion if you travel by car and drive it yourself. Driving a car requires *g* all the time;* cycling only sometimes. Women, too, turn leagues of wool into acres of straightforward knitting while occupied with other matters. But if the knitting is at all complicated, even the smallest of small talk inevitably interrupts it. It has already been said that neither purely habitual nor innate activities demand *g*; and these quite definitely do not suffer in competition with those that do.

4. AFFECTIVE COMPETITION

But it is not merely cognitive events which jostle each other in and out of awareness. The writer was once present when a small boy and his Head Master, each pursuing some urgent matter in a manner becoming to his station in life, approached along two corridors which met at right angles. Neither was aware of the other until they met at the corner, the small boy's head in his elder's stomach. Each was speechless. In the one case it was probably mingled surprise and indignation that inhibited the cognitive processes which,

* Cf. p. 263.

at a later and calmer moment, matured as a reprimand. But as for the small boy, who in those days had never heard of introspection, as far as he can remember now, a feeling almost of having committed sacrilege blended painfully with fear and uncertainty, while mirth—unwanted and incongruous, but almost irrepressible—helped to complete his intellectual disintegration. He certainly stammered a purely habitual " I'm awf'ly sorry, sir " ; but this was followed by an attempt at explanation or excuse which failed to be comprehensible even to himself.

But the deleterious effect of emotion upon cognition is so well known that it requires little further elaboration. The violent hysteric is incapable of thought. " Thou art an ecstatic ", says the Caliph in *Hassan*, " and wilt not suffer, I know the thick skins of martyrs " (1). Passing the churchyard after dark the superstitious bumpkin " whistles to keep himself from being afraid " ; though he could hardly explain that the cognitive and conative content provided by the whistling of necessity keeps at bay the affective content he seeks to avoid. And it is notorious that in matters concerning western religions, where the affective elements are predominant, unbiassed or dispassionate thinking is very exceptional indeed. Propagandists of all kinds make constant use of this power of emotion to obstruct and even inhibit deliberation, choosing words which tend to arouse the feelings they desire, rather than the calm thought which might well prove fatal to the cause they are advocating. Thouless has it that " There is a well-known saying that the word ' firm ' can be declined as follows: I am *firm*, thou art *obstinate*, he is *pig-headed* " ; and goes on to say " ' Firm ' has an emotional meaning of strong approval, ' obstinate ' of mild disapproval, ' pig-headed ' of strong disapproval " (2). The point is that while one is experiencing " strong disapproval ", thought as

to whether that emotion is justifiable or not remains impossible.

The conclusion is, again, that we can become aware of so much and no more; and if affective states monopolize consciousness, they can do so only by first ejecting other processes, including those of cognition.*

5. CONATIVE AND VOLITIONAL COMPETITION

It is a matter of common experience that cognitive efficiency is impaired not only by the competition of other cognitive processes, and of emotional states, but also by conditions of pronounced mental effort. Let the reader set himself a time limit of two minutes, and try to solve the following classic problem mentally. A wooden cube with sides *three* inches long is painted red, and is then sawn into as many cubes as possible each with sides *one* inch long. How many small cubes are there? How many will have paint on four sides? How many on three sides? On two? On one? And on no sides at all? It is easily possible to try so hard that one's cognitive processes are considerably hampered. There is a tendency, if the problem is difficult and the incentive great, for the actual trying to monopolize consciousness at the expense of the productive activity. In short we become aware of our conations, and no longer aware of the task in hand.†

As far as volition is concerned, the present writer would with diffidence put forward the view that, at the moment of choice, of decision, or of resolution, he at any rate is conscious

* The following appeared in *The Manchester Guardian*, July 28, 1934: "*A problem doctors cannot solve.* Dr. Macdonald Critchley, of London, spoke of a . . . man who, in the course of a heated political argument, was struck violently on the head by an umbrella. The umbrella was broken to matchwood, but the enthusiastic politician went on with his harangue without knowing that he had been struck"

† Cf. Appendix 4, § 7.

of himself as giving assent to whatever it may be, and of nothing else. All normal cognitive, affective and conational states seem to be momentarily banished, their place being occupied by a quite special sort of awareness of his own ego, or self, as willing so-and-so.

6. TWO FURTHER OBSERVATIONS

Two further observations seem worth making.

(A) Span. First, it is remarkable how little it is that can be cognised in a single flash of awareness. If a series of cards, each having a number of dots arranged *haphazardly* on it, be exposed in turn for a fraction of a second, it is easy for most people to tell how many dots there are, provided there be no more than four or five. But it becomes difficult to grasp six dots as six; and for most people seven or eight or more definitely exceed the span of instantaneous cognition; the observer is forced to admit that he could not tell how many dots there were.

(B) Automatic writing. Secondly, it possibly seems to a casual glance that this law of the constancy of cognitive output may break down in certain pathological cases. In states of acute dissociation people are able to carry on a conversation on one topic while writing an account of something quite different. Usually there is evidence, however, that the patient is conscious of one process only, and not of the other. He is aware of what he is saying, perhaps, but has no conscious control over, or knowledge of, what he is writing (3). The entire phenomenon, which is usually, and probably rightly, termed "*automatic* writing", seems to stand in need of much further careful observation. It may, perhaps, be merely another example of the uneven distribution of awareness; one activity going on at the focus, and the other in the margin, of consciousness. But, however

anomalous it may superficially appear to be, our present knowledge of it hardly suggests that it constitutes an exception to the law here discussed.

7. CONCLUSION

The upshot of this chapter is that " To do two things at once is to do neither " (4). Cognitive output is limited ; at any moment we can apprehend but the merest fraction of the totality of possible cognitive, affective, conative and volitional experiences ; and, as the awareness of one fades, its place is immediately usurped by another. It is this fact, this absence of a vacuum in experience, which enables us to enunciate the LAW OF CONSTANT COGNITIVE OUTPUT, namely, that *cognitive output tends to remain constant in quantity, though varying in kind.* In Spearman's words, " A man's stream of lived experience runs in such a tiny bed, that anything entering into this must needs displace some previous occupant. Of all the competitions for existence, of all the wars for ' a place under the sun ', surely none is more relentless than that which is continually waging between the various contents of our own mind " (5).

REFERENCES

(1) *Hassan,* Act 3, scene 3, James Elroy Flecker.

(2) *Straight and Crooked Thinking,* p. 13.

(3) See, for example, the accounts in Sir W. F. Barrett's *Psychical Research,* chaps. 15 and 16.

(4) Publius Syrus, quoted by Spearman, AM, p. 102.

(5) AM, p. 99.

CHAPTER NINE

RETENTIVITY: 1. FACILITATION

A: FACILITATION OF ISOLATED EVENTS

1. "PRACTICE MAKES PERFECT."
2. THE STAMPING IN OF ERROR.
3. ELUCIDATION AND EXPERIMENT.
4. ERRATIC IMPROVEMENT.
5. FACILITATION AND ACTIVITIES NOT REQUIRING *g*.

B: FACILITATION OF PAIRED EVENTS

6. ASSOCIATION.
7. "CONDITIONING."
8. TERMINOLOGY.
9. THE IMPORTANCE OF ASSOCIATIONS.
   (*A*) In normal mental life.
   (*B*) In pathological cases.

The LAW OF RETENTIVITY may be stated in the following terms; *the occurrence of any mental event is followed by a tendency for it to recur.* This tendency is manifested in two ways, FACILITATION, which is treated in this chapter under two headings; and PERSEVERATION, to which chapter 10 is entirely devoted.

A: FACILITATION OF ISOLATED EVENTS

1. "PRACTICE MAKES PERFECT."

It is a well-known fact of casual experience, as well as of accurate experimentation, that *mental events tend to recur more easily than they first occurred.* We only achieve full mastery of all but innate mental processes by repetitions of them. In common language, we "learn by experience", and "practice makes perfect".

2. THE STAMPING IN OF ERROR

Nevertheless, the most striking examples of facilitation come from the realms of failure, not from those of success. The boy who has spelt a word wrongly, and who has merely noted the fact without making a deliberate effort to memorize the correct form, is far more likely on the next occasion to repeat his mistake than to spell the word aright. His original faulty cognition will more probably be followed by a repetition of itself than by the correct but slightly different word. The same is true in speech. The present writer finds it almost impossible not to say " simultaneous " with a long " i ". The short one, he has learned too late in life, might temporarily disguise his ignorance of Latin and of the latest methods of pronouncing it. But it will never now have the facilitation the other has had. A last example. When a boy at school the present writer was always called " Davis " by one particular master. Possibly, on first making this mistake, the latter felt that *any* Welsh name was quite adequate. Facilitation, coupled perhaps with some indifference to a small boy's feelings, did the rest. To him, I remained " Davis " until the end of my school career.

3. ELUCIDATION AND EXPERIMENT

It is clear that the special realm of facilitation is that of learning and habit-formation ; but fuller discussion of this belongs more properly to the next section.* Here it will be added only that when mental events are said to recur *more easily* than they first occurred, we mean merely that they become responsive to weaker excitants, or occur more rapidly, or with greater intensity than on their first occurrence.

* § 7, p. 73.

These manifestations of facilitation can all be observed in conscious experience in performing the following experiment. Make, preferably on squared paper, several copies of the same geometrical figure, say, of a star; and place one on the table so that it is hidden from the experimenter's eyes by a screen under which his hand can pass and move freely. A mirror is now arranged in an approximately vertical plane, so that he can see the reflection of the star (Fig. 48); and he tries to trace its outline with a pencil. For most people this "mirror drawing" is at first quite amazingly difficult, for the reflections of the wrist and hand movements are most misleading. But practice on the other copies of the star brings rapid improvement, which can be assessed in several ways. The simplest is to note the decreasing time required for successive trials. Another is to note the number of times the pencil leaves the outline or moves in a wrong direction. A third is to count the number of squares between the original outline and the tracing. Fig. 5 shows the results obtained by one experimenter over nine trials, the measure of success being a compound of the three mentioned above.*

4. ERRATIC IMPROVEMENT

This experiment brings home the fact that during the acquisition and perfection of any skilled activities we have our periods of rapid improvement, of temporary stagnation, and even of actual regression; for it is almost unknown for each repetition of such a task to prove more successful than its predecessor. This merely stresses once more the very problem which is occupying us at present, namely, variations in capacity. We may say, then, that the effects of facilitation

* This simple experiment is well worth the actual performance. A modification of it is, however, suggested in Appendix 3, § 8, p. 305; and the reader is strongly advised to undertake it in the form suggested and illustrated there.

by repetition are cumulative in a superficially rather wayward fashion; and tend, as is well known, to disappear with the lapse of time if further repetitions are neglected.

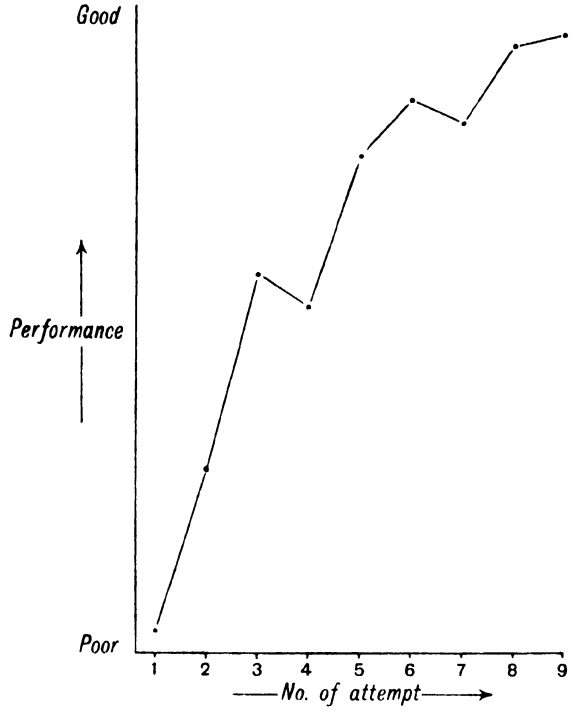

FIG. 5

But the waywardness is, of course, only superficial; and is to be accounted for in terms of the quantitative determinants discussed in the other chapters of Part 3.

5. FACILITATION AND ACTIVITIES NOT REQUIRING *g*

It is to be added that the effects of facilitation are not confined to activities which demand *g*. It is well established that the nest which a bird builds at its first attempt is seldom as good as those which it builds in later years; and nest construction must be regarded as an activity in which inherited, rather than learned, tendencies predominate. As

for habitual activities, it is surely here, if anywhere at all, that "practice makes perfect". It may be said that the tendency of facilitation is to make performances automatic and independent of *g*, thus freeing the latter for more subtle activities. In the early stages of learning to drive a motor car, for example, one's *g* may be fully absorbed by the steering alone; none being left for the other controls. The law of constancy of cognitive output will be remembered here (cf. chap. 8).* Then it is that, in an emergency, the novice seems "paralysed"; and may fail either to slow down or to give warning of his approach. Later on use of first one control and then of another becomes more and more facilitated, and *g* is freed from the *s*'s which subserve them. Steering, braking, gear-changing, signalling to other road-users both in front and behind, and the rest, may then become almost automatic; and *g* may be employed chiefly in "nursing" the engine, or in anticipating difficulties; or, of course, if one is that sort of driver, in conversation.

B: FACILITATION OF PAIRED EVENTS

6. ASSOCIATION †

The particular case of facilitation to be discussed now is best stated as the law of ASSOCIATION, namely, that *mental events which occur together tend to do so subsequently with greater ease.* The underlying fact has, of course, been recognized since the days of Aristotle. More recently Herbart and his followers have stressed its importance, particularly from the educational point of view. Still more recently the realm of association has been explored to the exclusion of all others by the Russian physiological School of Pavlov (1); and also by the American Behaviourists, notably Watson (2).

* See also chap. 28, § 8, p. 263.

† Discussion of association is resumed on p. 163.

7. " CONDITIONING "

Pavlov's experiments on dogs illustrate the associative process working at an almost physiological level. A hungry dog is made to experience together on several occasions the sound of a bell and the physiological process of salivation, the latter being produced by giving him a piece of meat. Henceforward there is a tendency for the sound of the bell to be always accompanied by a secretion of saliva even when no meat is forthcoming ; and the association between them is rendered more and more effective by repetitive facilitation (3). Watson's experiment on infantile fear illustrates the association of combined cognitive and emotional material. A baby is made to experience at the same time the sight of his *pet* rat and the emotion of fear, the latter being produced by making a sudden very loud noise close to him. From then on the sight of the rat tends to evoke fear in the child (4). On a still higher plane come such phenomena as a child's learning the meaning of a word he hears. His mother shows him his plaything, uttering at the same time the word " Teddy ". He strives to mimic the sound she makes (an orectic tendency) and after a few successful repetitions, when visual cognition of the " teddy " happens to occur, it will tend at once to summon forth the vocal experience. The child now says " Teddy " himself, without any further prompting from mother ; and we say that he has *learnt* the word, and *means* by it just what other people mean. Again, association has probably played a part when misprints in a text are passed unnoticed. The letters *remai* are associated for most of us so intimately with the letters *nder* that they may well be sufficient to convey the meaning of the entire word. If so, then the last group of letters need not be seen at all ; and the substitution of *u* for *n* will tend

to pass unnoticed—unless the eye happens accidentally to focus upon it. A last example may be given from my own personal experience. I had spent the morning indoors in a pair of bedroom slippers, but otherwise completely dressed. When ready to go out I looked for my shoes in the usual place downstairs; and failing to find them, went to the bedroom to seek them there. A few minutes later a sudden burst of sunshine on the bathroom window made me realize that I was cleaning my teeth at a rather unusual hour. It only remained to resume collar, tie, waistcoat and jacket, and to start hunting for the shoes all over again.

8. TERMINOLOGY

At the moment it is the vogue to avoid the word "association" in this context, and to speak instead of "conditioning". The boy who experiences fear of a barking dog when in a dark and narrow passage, and in whom the fear is subsequently associated with the darkness and with enclosed spaces, is said to have had his fear "conditioned" to these new stimuli, just as my own undressing and teeth-cleaning reactions were "conditioned" to the sight of the bedroom. It is a little difficult to understand what is gained by this new terminology. The two words mean just the same; while "association" has a big advantage of obviousness which "conditioning" lacks.

9. THE IMPORTANCE OF ASSOCIATIONS

The most systematic discussions of association are to be found in the writings of the Behaviourists and of the Psychotherapists. Here it will be sufficient, first, to stress something already implicit in the examples given; namely, that cognitive occurrences can, and frequently do, enter into association with each other and with orectic processes of

all kinds ; and, secondly, following from this, that in performing any particular cognitive process *X*, the association of another process *Y* will enhance its efficiency in so far as *Y* is relevant to it, but will hinder *X* in so far as it is irrelevant.

(A) In normal mental life. For example, if, while playing golf, the act of placing a tee " calls to mind " the fact that I " topped " my last drive so badly that the tee was almost buried in the ground, so much the better ; I can now take special precautions on this occasion. But if the same act merely " reminds me " that last week I lent my opponent a half-crown to buy some tees, and that I have not since seen even the change, the resulting emotional effect will almost certainly impair my impending drive. Another example : I once knew a man to whom the word " commence " acted as a conditioned stimulus to which his invariable response was a snort. It inhibited all useful cognitive processes until he had explained that " begin " was the only possible word to use in that context.

(B) In pathological cases. Association also plays a great part in producing many pathological states ; and all schools of psychotherapy lay special emphasis on tracing a patient's associations as a means of discovering the origin of his complaint. Psychoanalysts particularly examine the associations of dream-items. Freud, for example, records a dream of his own in which *spinach* occurred (5). On tracing the associations subsequently, *spinach* was found to be linked up with an incident which had recently occurred to him, and also with details of his own childhood. Associations lie also at the root of much pathological symbolism. " The hand-washing mania ", says Hadfield, " usually signifies a deeper but unrecognised stain of soul " (6). For us, the most significant word is " stain ". Associations can also be made to play a part in certain methods of treatment as well as of

diagnosis. The same writer speaks of the cure of a drug addict who, by suggestion, " was made vividly to picture himself *passing* certain shops where he got the dope, the idea of a chemist's shop being thus associated with the idea of passing it. The suggestion was so effective that he complained later, ' I found the greatest difficulty in going into a chemist's shop to get a toothbrush ! ' " (7). Those familiar with Frazer's *Golden Bough* know already that magical practices are there traced wholly to associative processes.

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(1) I. P. Pavlov, *Conditioned Reflexes* and *Psychologies of 1930, A Brief Outline of the Higher Nervous Activity.*

(2) J. B. Watson, *Psychology from the Standpoint of a Behaviorist; Behaviorism;* and *Psychologies of 1925,* Part 1, *Schools of Behaviorism.*

(3) Pavlov, *op. cit.*, p. 290 *et seq.*

(4) Watson, *Behaviorism*, p. 158 *et seq.*

(5) S. Freud, *On Dreams*, trans. Eder, p. 9 *et sqq.*

(6) J. A. Hadfield, *Psychology and Morals*, p. 29.

(7) Hadfield, *op. cit.*, p. 149.

CHAPTER TEN

RETENTIVITY: 2. INERTIA

1. ORECTIC INERTIA.
2. COGNITIVE INERTIA.
   (*A*) On the perceptive level.
   (*B*) At higher levels.
3. DEVELOPMENT.
4. *P*, AND MENTAL "TYPES".
5. *P* AND *c*.

1. ORECTIC INERTIA

The LAW OF INERTIA states that *mental events begin and cease more slowly than their apparent causes.** That this is so is particularly obvious in the realm of orexis. It may be an appreciable time before bad news excites actual grief; but when the emotional response does come, it may be of very great duration. The same is true of conation, though hardly of volition. A boy's prowess in the examination room or the swimming bath may not immediately excite his friend's emulation; although later on it may give rise to a long series of most strenuous endeavours. But, for the psychology of ability, it is cognitive inertia which is most important, and to which the rest of this chapter will be devoted.

2. COGNITIVE INERTIA

(A) On the perceptive level. A simple example, with which everybody is familiar, though, maybe, without knowing it, is that of visual inertia as exploited by the cinema.

* The phrase "*apparent* causes" conveniently avoids the (here irrelevant) argument as to what the "*real* causes" of mental events may be.

A cinema film consists of a number of snapshots or *stills* which have been taken with very great rapidity one after another. Each, then, depicts the same scene as its predecessor, but at a slightly later phase. The sequence of *stills* is jerked through the projector in such a way that each is momentarily focussed on the screen before giving place to the next. But, between the exposure of one *still* and that of its successor, an opaque shutter intercepts the beam of light. The detail of what happens is, therefore, as follows:

1. The first *still* is focussed on the screen.
2. The shutter cuts off the light, and during the ensuing brief period of darkness the first *still* is jerked away and replaced by the second.
3. The shutter opens and exposes the second *still.*
4. The shutter closes while the second *still* gives way to the third; and so on.

All this happens some sixteen times every second; but although the screen is actually in darkness nearly half the time (say, on some 150,000 separate occasions during an evening's performance),* it appears to be steadily and completely illuminated all the time. This is because the *stills* are made to succeed each other so rapidly that our cognitions of one have no time to fade before the next is already being cognized.

The fact is, then, that our visual experiences do not cease at the instant their causes cease. They "lag", or possess inertia; tending to drag on even after their stimulus has been removed. This phenomenon is frequently referred to as that of *perseveration.* It can be said that at the cinema we experience an illusory constancy of illumination, and an illusory continuity of movement, since our cognition of one

* I.e. nearly twice as many times as there are words in this book.

still " perseverates " long enough to blend with our cognition of the next.

(B) At higher levels. Perseveration, or inertia, seems to be the rule throughout the entire realm of cognition ; and it is of considerable importance for the psychology of ability. It means that between any two different cognitive perform-

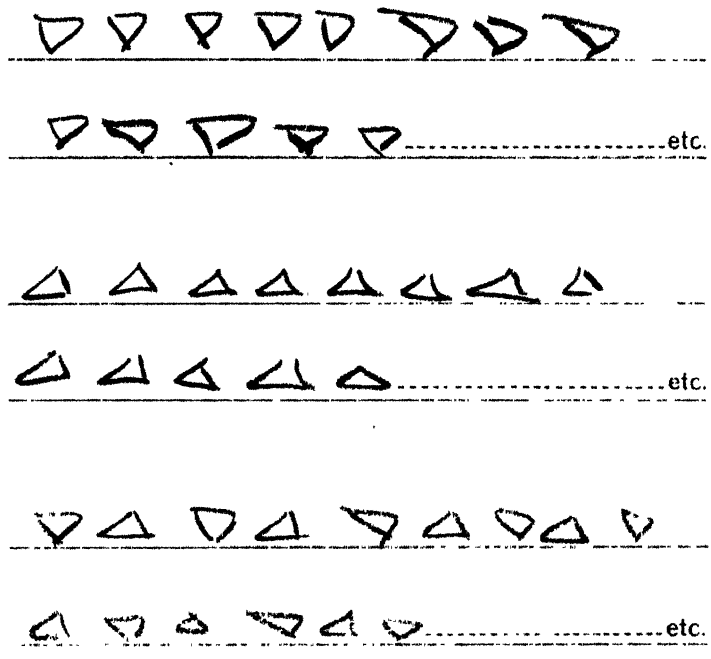

FIG. 6

ances there should be at least a brief period during which perseveration of the first has time to die away. Otherwise, by its own inertia, it will linger on and—since cognitive outputs tend to be constant—hinder the second. A simple experiment in perseveration is to draw triangles as rapidly as possible base upwards (Fig. 6a), for exactly half a minute. After a few seconds' rest, another group should be drawn, apex upwards (Fig. 6b), also for exactly half a minute. Both

sets should now be counted, and if one group contains many more triangles than the other, both should be scrapped, and the performances repeated with a brief pause between each, until the two tasks can be carried through with about equal facility. When this has been achieved, one uninterrupted minute should be spent drawing triangles alternately base upwards and apex upwards (Fig. 6c).

A measure of perseveration is then given by subtracting the number of triangles drawn in the last minute from the total of those drawn in the previous two half-minutes. There is certain to be a loss of efficiency at the second performance as compared with the first, though, mechanically, the two tasks are identical. Each consists merely of drawing triangles one way up for half a minute, and the other way up for another half-minute. The loss in efficiency is therefore due to the fact that the first performance takes place in two uninterrupted portions, while in the second interruptions are as numerous as the triangles themselves. During the first minute, inertia has but one opportunity to manifest itself, namely, at half-time, when *g* is switched from one *s* to the other. But during the second minute the number of opportunities for perseveration to occur is only one less than the number of triangles the experimenter actually draws; for, after each, *g* has to be transferred to the other *s*. Thus in the second minute fewer triangles are drawn, for the performance of each is impaired by the perseveration of the previous contrasted performance.

3. DEVELOPMENT

Two features of inertia are worth mentioning here. First, perseveration does not, as it were, seem to discriminate to any extent between cognitive performances, but affects them all, in the same person, to much the same degree (1). In this

sense it must be regarded as a second general factor, since, like *g*, it influences *all* cognitive tasks, whether simple or complex. For this reason the symbol *p* is often used to represent the common perseveration-factor, or tendency to inertia, of a person's cognitions; just as *g* represents their common quantitative aspect.* It is, however, obvious that the *p*-effects of one activity on another will be much the most marked in the earliest phases of the second; and will, if the latter be homogeneous and prolonged, tend to wear off in time. Secondly, it is important to note that even normal people vary enormously in the extent to which they perseverate †; while, in the pathological sphere, the differences are still more striking. Melancholics, on the one hand, are said to show very marked *p*; and hysterics, on the other, to be very much less perseverative than normal people.

Another point remaining is to stress the connection of inertia with the problem of this part of the book. Clearly your success at any task will depend in part upon what you have just been doing, and in part upon your *p*. If you are highly perseverative and have just been doing something wholly dissimilar to your present occupation, then that will tend to mar your performance considerably, in its earliest phases at least.

4. *P*, AND MENTAL "TYPES"

This is the place in which to justify an assertion which has been made twice already (pages 21 and 32), namely, that

* The use of the term "factor" in this connection is discussed on page 119.

† In an experiment performed with me by 35 secondary school boys aged from about 15 to 18 years, the losses varied between 4% and 63%, the bulk of the cases (23/35) lying between 11% and 30%. The experiment was not, however, performed under rigorous conditions. Normal adults whom I have tested from time to time have shown losses varying between 5% and 59%.

there is some truth in oligarchic views of ability-" types ". The truth is that people who have been termed " subjective ", " introvertive ", " deep-narrow ", and so on, do tend to be definitely more perseverative than do those who, in contrast, have been called " objective ", " extrovert ", " broad-shallow ", and the rest. Underlying such two-fold classifications as these of " mental types " there is a real foundation of statistically observed and established differences, namely in *p*. It must be added, however, that the " surgent-desurgent " distinction has a different basis.

5. *P* AND *C*

A statistical analysis of nearly 50 character traits (2) revealed the existence of a general factor which merits discussion here. Such traits as—

sense of humour,	(.98)*
general tendency to be cheerful,	(.97)
quickness of apprehension,	(.95)
originality of ideas,	(.88)
love of large gatherings,	(.85)
and, intensity of personal influence on associates	(.84)

were found to be highly saturated with this factor; while such traits as—

susceptibility to occasional general depression,	(−.57)*
pure-mindedness,	(−.45)
and, interest in religion,	(−.39)

were found to be correlated fairly closely with its absence.

Two attempts have been made to account for these facts. The first holds that we have evidence here of a third general

* The figures in parentheses are the correlation coefficients between *c* and the traits indicated. (Cf. Appendix I.)

factor, which is usually termed *c* to indicate its suspected connection with some basic trait which may best be described, perhaps, as *cleverness*. But other work seems to disprove the separate existence of such a trait as this ; and a second, alternative hypothesis has been put forward to account for *c*. This view equates *c* to the absence of *p* ; thus once again linking differences in *p* with differences in temperament and character. In this view, sense of humour, cheerfulness, quickness, and the other traits in the first of the two lists above, tend to be a characteristic of *non*-perseverators. Similarly, susceptibility to depression, and the rest, appear to be associated with a high degree of *p* (3).

It must be stressed, however, that it has by no means been definitely established yet that *p* and *c* are, as it were, reciprocals one of the other ; but this certainly appears to the present writer to be the more plausible hypothesis. Pending further investigations we may tentatively regard *p* and *c* as symbolizing, respectively, the positive and negative aspects of the former trait.

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(1) Cf. for example, Ll. Wynn-Jones, *J. of the N.I.I.P.*, iv., *Individual Differences in Mental Inertia* ; E. Bernstein, BJP, PM 7, *Quickness and Intelligence* ; and J. W. Pinard, BJP, July and Oct., 1933, *Tests of Perseveration*.

(2) J. C. Maxwell Garnett, *General Ability, Cleverness and Purpose*, BJP, 1919.

(3) Cf. AM, pp. 354 *et sqq*.

CHAPTER ELEVEN

FATIGUE

1. Fatigue Opposed to Facilitation.
2. The Terms "Subjective" and "Objective"
3. The Terms "General" and "Specific".
4. Subjective (Specific) Fatigue.
5. Objective Fatigue.
   (*A*) Specific.
   (*B*) General.
6. Additional Note on Boredom.
7. Illustrative.

1. FATIGUE OPPOSED TO FACILITATION

Fatigue is the name given, sometimes rather loosely, to a fairly complex group of phenomena. The fundamental fact in the psychology of cognition, which therefore constitutes the basic Law of Fatigue, is that *the occurrence of any cognitive event is followed by a tendency for it not to recur.* The effects of fatigue, then, are diametrically opposed to those of facilitation (chap. 9). This is shown during a long spell of cognitive activity. At first the rate of working tends to increase, the processes gaining in efficiency as the effects of facilitation accumulate more rapidly than those of fatigue. But in time these advantageous effects may be more than offset by the increasing burden of fatigue; and the time may come when efficiency tends to improve no longer, and finally diminishes.

The classical experiment on fatigue is that of Miss Arai, who, after sufficient practice, was able to multiply, *mentally*, 67 pairs of four-figure numbers on each of four successive days (1). Each sitting required about twelve hours, and no

pauses were taken for rest or food. Fig. 7 shows the average time taken over the four days to perform four successive

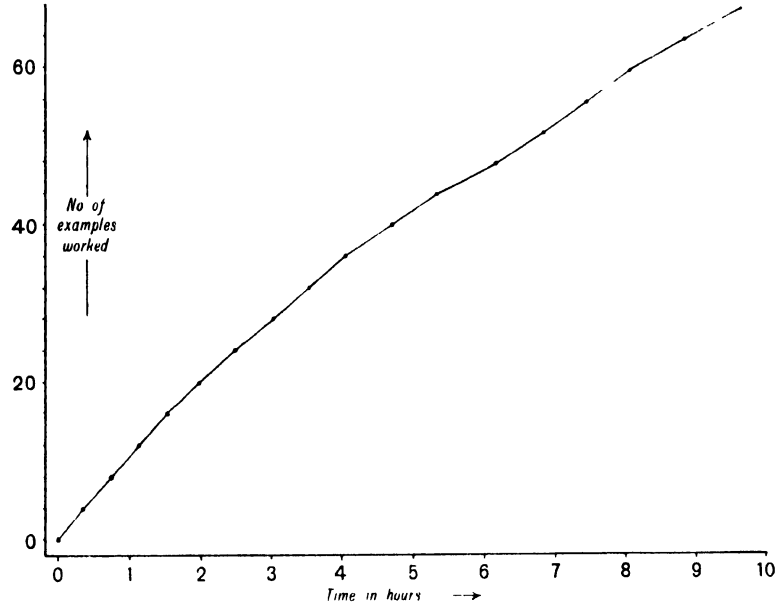

FIG. 7

calculations, and shows clearly both the onset of fatigue and also what a surprisingly small diminution in output actually occurred during this formidable task.

But " fatigue " is an equivocal term, including and confusing phenomena of no less than three distinct kinds.

2. THE TERMS " SUBJECTIVE " AND " OBJECTIVE "

In the first place objective fatigue, which represents a real loss of efficiency, must be distinguished from subjective fatigue, which is only an apparent loss, for it can be abolished in a moment by excitement or by an act of will. Let us take an imaginary example which brings out the contrast admirably. Suppose that you are returning after a long day's tramp, say, among the mountains and valleys of the Lake country. The fine weather has tempted you into a detour

which has proved much longer and more arduous than you anticipated. Being unfamiliar with the country, you dared not risk a return after nightfall; and so you toiled reluctantly on past the farmstead where you might have had tea. Now, as the light fades, you come hungry and footsore within sight of your destination. The quiet of the evening is shattered by a noise from behind. You look round apprehensively. An irate and uncompromising bull is making straight for you. Fortunately cognitive content is limited, and the bull is likely to take full possession of consciousness, leaving none for the realization of fatigue. The high stone walls that enclose the narrow road are unscaleable; you tried to climb some during one of the day's short-cuts. The only chance seems a low gate more than a hundred yards away. It hardly needs saying that you will shed the day's fatigue as readily as a small boy sheds decorum when his master leaves the class; and you will sprint that hundred yards with an agility that was seldom yours, maybe, even in youth. And the nearer the bull gets, the faster you will sprint. It is a hard saying, but true, that much of the fatigue induced even by a long day's strenuous tramping is subjective; not a real loss of efficiency, but an imaginary one. An act of will could banish much of it. So could the encouragement of finding unexpectedly that one's destination was but a stone's throw away, instead of the several miles one had anticipated. So would the bull. In fact, the bull would certainly banish most of it; but not quite all. Had he intruded upon you at the beginning of the day instead of at the end, your sprinting would have been even more competent. As it is, the day's exertion will have provoked some real loss of efficiency, that is, a little objective fatigue. Your leg muscles and their neurones will be charged with toxic products of activity which have formed too rapidly for their

absorption to keep pace. In so far as this has occurred, your powers of sprinting will have undergone a real deterioration, which can only be repaired gradually by resting. But none the less the bulk of the fatigue that such an excursion would produce is not of this type. It is imaginary rather than real; subjective, not objective; and, in the absence of a suitable bull, this part can be effectively banished—*if we will.*

3. THE TERMS "GENERAL" AND "SPECIFIC"

In the second place the distinction must be made between *specific* fatigue, where the effects are limited to the operation that induced it, and *general* fatigue, where the effects spread throughout the system and impair to some extent all other performances. Examples illustrating this distinction will be given in a moment. At present it must be pointed out that "subjective fatigue is wholly specific, whilst objective fatigue is partly specific and partly general" (2). Thus there are, in all, three different kinds of fatigue; and these will now be considered separately, and examples given where the mental aspects are more dominant than in the situation described above.

4. SUBJECTIVE (SPECIFIC) FATIGUE

An example of this kind of fatigue is provided by the boredom induced by any protracted and uncongenial cognitive operation. One effective method of inducing it experimentally is to take a number of sheets of paper, each covered with single figures, and to keep on adding the figures three or four at a time and writing the answers down. It will not be long before the monotony of the task induces considerable boredom, that is, subjective fatigue. But this will be specific. Its effects will be limited to adding figures. If you turn to a different task, for example, that of reciting some

poetry or prose or meaningless syllables you have learnt in another experiment, your ability here will be normal; and this would still be so, even if the new task resembled the old fairly closely. In short, subjective fatigue tends to be non-transferable from the task that induced it to others; it is specific and not general.

5. OBJECTIVE FATIGUE

(A) Specific. This, by definition, is the real loss of efficiency caused by, and limited in its effects to, a particular task. To revert to our example of adding figures. If we stay at it long enough, our success will progressively diminish even though we have so adequate an incentive to continue at our maximum rate that boredom does not arise. No act of will, excitement, or extra stimulus can eradicate this. The only method of doing so is to stop work and so allow recuperation to take place. In time this will occur as inevitably and automatically as the fatigue itself did.

(B) General. The same example shall serve for the last time. Adding figures for a sufficiently long period will give rise to a condition in which all other mental processes undergo a real deterioration. This, again, can only be eliminated by rest.

But a very interesting phenomenon has been noticed in connection with this variety of fatigue. It is that in any given person some activities are more affected by transference of fatigue than others. Let us suppose that performance *A* has induced some objective general fatigue in a subject. This may affect his subsequent performance at *X* far more than at *Y* or *Z*. If so, then it will also happen that excessive activity at *B*, *C*, *D*, or anything else, will also affect *X* more than *Y* or *Z*. In Spearman's words, the subject has for *X*, "a chronic liability" to fatigue (3).

6. ADDITIONAL NOTE ON BOREDOM

Two things seem worth adding. First; in another sense, very different from that used in paragraph 4, boredom *is* general. It is a well established fact that a person who is readily bored by any one sort of occupation, is also the person who gets bored easily by other sorts. In other words, if A is bored by x and B is not, then *ipso facto* A is more likely than B to be bored by y or z also. In this special sense boredom can certainly be said to be general (4). Secondly; it is worth noting that boredom is seldom quite so deleterious as it seems to its victim. When utterly ennuyé, one feels as though efficiency had fallen to zero; but in actual fact, unless, of course, activity ceases altogether, nothing of the sort really happens. Work does truly suffer, but not nearly as much as it seems to at the time.

7. ILLUSTRATIVE

Let us sum up this rather complicated discussion by considering a concrete, if imaginary, example. A Latin period has induced some fatigue in a certain boy. Let us suppose that he is conscientious, ambitious, and usually near the top of his Form by virtue of exceptional talent at Science and Mathematics. But let Latin be his worst subject; and let the master, on this occasion, give a thoroughly dull and uninspiring lesson. The fatigue may then be assumed to be partly objective, an absolute loss of efficiency due to sheer hard work; and partly subjective, that is partly mere boredom, due to dull teaching and the boy's own lack of real interest in the subject. For simplicity we can suppose that quantitatively the total loss of efficiency at Latin is by the end of the lesson 20% of his efficiency at Latin at the beginning. Of this loss we can put 12% as due to objective, and 8% as due to subjective fatigue. Now we must inquire

what happens to that fatigue when the Latin period ends and he starts an Algebra lesson. First of all the 8% loss due to mere boredom will vanish at once, for subjective fatigue is never general. If he disliked Algebra as well as Latin, the first state of boredom would soon be replaced by a second; but the first would not itself transfer to the new task. Thus, as far as subjective fatigue alone is concerned, the boy would start Algebra with 100% efficiency. But what of the 12% Latin efficiency, which was absolutely lost? Some of this objective fatigue, say, 7%, will be general, and so this will affect in some degree Algebra as well as Latin. But the remaining 5% will be specific and will not transfer to the new subject. Thus, although the boy finished Latin with 80% of the efficiency with which he started it, he will begin his Algebra with perhaps 92% or 95% of the efficiency he would have had if the Latin had not come previously. The exact percentage all depends on the extent to which Algebra is "chronically" affected by real fatigue otherwise induced. The 7% Latin loss, due to objective general fatigue, may transfer in this boy's case as an 8% or a 5% Algebra loss, whereas in the same boy it might transfer as only a 2% French loss, or a 15% Geography loss.

REFERENCES

(1) Tsuru Arai, *Mental Fatigue.*
(2) AM, p. 313.
(3) AM, p. 316.
(4) AM, p. 314.

CHAPTER TWELVE

COGNITIVE VARIABILITY

1. The Phenomenon.
2. Up-and-Down Movements of Ability.
3. Movements In-and-Out of Awareness.
4. A Third Example.
5. Present Knowledge of *o*-Phenomena.
6. The Possible Importance of *o*.

There are many lines of evidence which make it imperative to postulate a Law of Cognitive Variability which must be stated as the exact antithesis of that of constant output (chap. 8), namely, that *cognitive output tends to vary continually in quantity.*

1. THE PHENOMENON

A simple example of this variability is provided by any sustained cognitive activity. It is found that output continually oscillates about some normal standard. At one moment it surpasses this norm; at another it decreases, only to recover normality again, to surge past, and then to fall once more, before repeating the cycle indefinitely. These flunctuations in efficiency are such that they have to be regarded as representing variations in the worker's own ability, for they continue even though the task remains of absolutely constant difficulty. Further, they appear to affect the whole gamut of cognitive activity; and, as such, oscillation, or, as it is usually symbolized in this context, *o*, must be regarded as a third general factor.

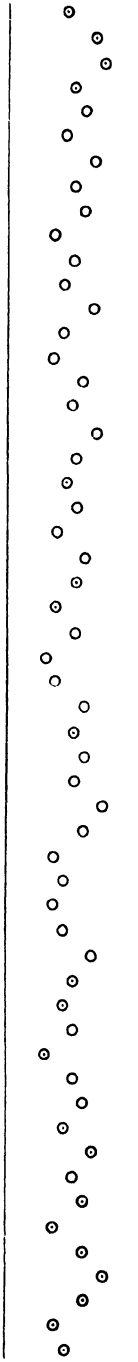

FIG. 8

2. UP-AND-DOWN MOVEMENTS OF ABILITY

A good example is provided by McDougall's "spot-dotting" apparatus. In this, a tape having an irregular pattern of small circles (Fig. 8) passes behind an open window at such a speed that the testee can put a pencilled dot in most of the circles as they pass. At times he will find it easy to dot every circle; at other times he will miss quite a number of them, although the speed of the tape remains constant throughout. In this example cognitive variability, or *o*, takes the form of an up-and-down movement of ability. At some moments we are more capable of dotting circles than at others.

3. MOVEMENTS IN-AND-OUT OF AWARENESS

There are, however, oscillations of another, and hardly less striking kind. There is a tendency for things to move in-and-out of consciousness. This may be illustrated by studying such a "reversible perspective" diagram as that of Fig. 9*. In this, the lower face of the cube will sometimes be seen in front of, and sometimes behind, the upper face; and these two contrasted views will alternate, sometimes quickly, and sometimes more slowly. It is obvious that the stimulus provided by twelve black lines on a white ground remains unchanged all the time; so the alterations in what

* Or even the ambiguous Fig. 18, p. 153.

is seen must be due to changes within the percipient. It must be remembered that cognitive output *tends* to remain quantitatively constant, so that when one view of the cube moves out of consciousness, its place is taken by the other.

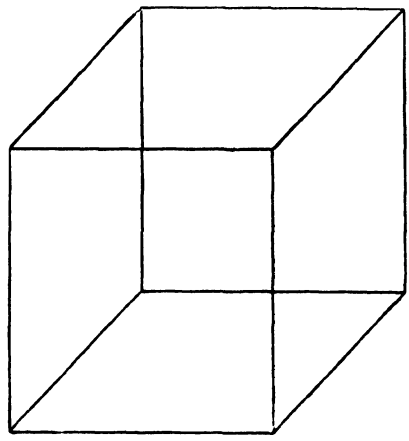

FIG. 9

4. A THIRD EXAMPLE

A last example, which suggests that these two ways of regarding cognitive oscillation may possibly be identical, is provided by listening to a watch placed just far away to be heard only with difficulty. The intensity of the tick will be found to vary from moment to moment. At times it will be comparatively loud; and at others almost inaudible. Once more the stimulus must be regarded as constant, and the changes in cognitive intensity are evidently the effects of some internal adjustment. But this time they may be regarded equally well as either movements in-and-out of consciousness, or as up-and-down movements of ability.

5. PRESENT KNOWLEDGE OF *o*-PHENOMENA

As we have said already, cognition seems always to oscillate quantitatively in one of these two ways. Dr. S. J. F. Philpott, to whom we owe the most thorough and systematic treatment of the subject so far produced (1), says of *o* that it " must be a very fundamental something. It appeared in the cold and draughty French house in which subjects Sm. and Ga. worked, great-coated, and huddled close to a smoky oil lamp with a broken chimney. It appeared whether they

were dotting, adding, or viewing an ambiguous drawing. It appeared in the quietness of the laboratory, and in the crowded class-rooms of an East End school, where street noises and occasional bursts of song from the infants below came rising to the top floors. It appeared in the curves borrowed from Thorndike" (2).

Professor J. C. Flügel, who, in an earlier study than Philpott's, dealt with *o* as one of a group of several problems, found that his subjects varied very much in the extent to which their outputs fluctuated; but that differences between individuals with respect to *o* are not as great as their differences in *g* (3). Philpott's work, where the time element of this phenomenon was carefully studied, revealed that a rather surprising regularity may underly the more obvious irregularities of output. This writer suggests that the basic curve of output may really be of the type shown in Fig. 10,

FIG. 10

in which the time between adjacent crests, or periods of maximum output, increases in a remarkably regular way which differs little from worker to worker or from one sort of task to another. Be this as it may, we must certainly think of ability as always in a state of flux. It ebbs and flows slightly but rapidly, oscillating about the average quantity which is typical of any particular person; and the success with which the latter will perform any cognitive operation varies from moment to moment.

6. THE POSSIBLE IMPORTANCE OF *o*

Clearly this phenomenon may be of tremendous practical importance, and will have to be studied in very much greater detail. In Spearman's own words, "there is the great task

of determining how this tendency to oscillate correlates with sex, race, social stratum, parentage, and above all, with vocational success. Let, for example, the following curve

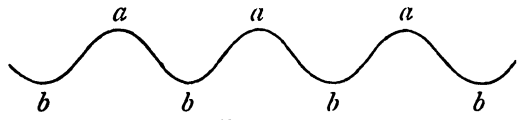

FIG. 11

(Fig. 11)* represent the course of the cognitive efficiency of any individual whose oscillations are of great amplitude. Suppose, first, that he devotes himself to inventing aeroplanes. In that case, his success will depend upon his highest points, *a*, *a*, *a*; as for his depths, *b*, *b*, *b*, no great harm will be done if here he is reduced to paralysis. But, suppose, instead, that his vocation is to *fly* aeroplanes, and just when some sudden peril arises, he happens to be down at one of the *b*'s!" (4).

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(1) Philpott, *Fluctuations in Human Output*, BJP, PM, 17.
(2) *Op. cit.*
(3) Flügel, *Practice, Fatigue and Oscillation*, BJP, PM, 13.
(4) AM, p. 328.

* It should be noted that this Fig. appeared *before* Philpott's work on the time-aspect of *o*.

CHAPTER THIRTEEN

CONTROL OF COGNITION

1. Conscious Control of Cognition.
2. The Effect of Conative Control.
3. Unconscious Control of Cognition.
4. Volition and Mental Set.
5. Set and Perseveration Contrasted.
6. *W*, or Persistence of Motive.
7. Conclusion.

1. CONSCIOUS CONTROL OF COGNITION

It is a matter of common experience that we are to some extent able to control our cognitions by trying to do so. (Cf. pages 61-62.) Someone is speaking to us in a noisy tube train, and we strive hard to catch what is being said; and the effort, maybe, is successful. Again, we fail to remember something of immediate importance, for example, the whereabouts of a letter which we must answer at once; and we "ransack our brains", striving hard to recollect where we were when we saw it last, what we might have done with it, and so on.

2. THE EFFECT OF CONATIVE CONTROL

The effect of such conative effort upon cognition appears to be a heightening of awareness. Not that we are aware of more than we were before; rather the reverse—we seem simply to have a more vivid awareness within a narrower field. Our cognitions become less *ex*tensive, but gain in *in*tensiveness. Cognitive output is, as we have said, constant; all that conation does is to concentrate it upon what seems to be the essence of the problem, and to withdraw

it from apparent irrelevancies. (Cf. page 60.) In short, the intensity of cognition can be conatively controlled.

It may be thought that conation can do more than this. But even in the extreme case in which, by striving to do so, we banish some obsessive memory, say, of a tune, we can only do so by making some alternative item of cognitive experience more intense, and so, by the law of constant output, ousting awareness of the first.

3. UNCONSCIOUS CONTROL OF COGNITION

But, besides these examples in which the control of present cognition is the result of conscious effort, we constantly meet other equally important cases in which the control is in a very real sense unconscious. Waking at a pre-selected time in the morning is a striking example of this. We have to get up at, for us, some unusual hour, and wake accordingly, having decided to do so overnight, and having slept soundly ever since. But other examples are only less striking because they are even more familiar. Indeed, they are happening to us all the time. The fact that, once we have begun a task, we normally tend to carry on with it, even though the motive for doing so has faded entirely from consciousness, is in itself an example. We only realize that control is involved if the task, though necessary, is very difficult or distasteful. Normally we decide to begin some particular undertaking. The necessary act of will is accordingly made ; and although we cease to be aware of this initial volition, it remains operative, and we continue with the task until it is complete.

4. VOLITION AND MENTAL SET (1)

It is usual to speak here of the volition as having given rise to a "mental set", or "determining tendency"; that is, to a disposition, of which we are quite unconscious,

for the activity which we have willed to continue until it is accomplished. It is only when the task is for any reason excessively irksome or difficult that mental sets tend to prove inadequate; whereupon the activity ceases, and we have to induce a new set by a fresh volition to see the job through.

The function of volition seems, then, to be as follows:

(1) It serves to initiate activity.

(2) It gives rise to an unconscious mental set which serves to sustain the activity.

(3) It serves to re-initiate activity which has broken down.

Clearly the distinction between (1) and (3) is arbitrary in the extreme, (3) being no more than a special case of (1).

5. SET AND PERSEVERATION CONTRASTED

But a warning must be interpolated here. This tendency of *ours* to go on with a task *until* we have finished with it, must not be confused with perseveration, which is *the task's* tendency to go on, merely through its own inertia, *after* we have finished with it.

The experiments illustrated in Figs. 6*a* and 6*b* are so simple that either can be carried through after a single act of will. But the experiment of Fig. 6*c* is on a different footing, and is worth repeating with a slight modification. It will be remembered that the instruction which has to be accepted is a double one.

(*a*) The triangles have to be drawn alternately base and apex upwards.

(*b*) They have also to be drawn as quickly as possible.

When the experiment was performed in Chapter 10, the emphasis was on the first of these two instructions; but if it be placed instead upon the second, an interesting phenomenon may appear. If you decide that, at all costs, you *will*

get as many triangles drawn as possible, say, ten per cent. more than at your previous attempt, there may be, after an initial mistake or two, a slowing-down to a rate at which mistakes cease. After a few seconds the realization will come that this will produce a result little better than the first; and a fresh resolution will be made to increase the rate of working.

Here the distinction between perseveration and volitional control is particularly obvious. It is due to perseveration that you tend to draw a triangle in one way when you want it to be in the other. But it is due to your mental set, volitionally engendered, (*a*), that you continue drawing triangles at all, instead of writing a letter or turning the wireless on; and (*b*), that you draw them faster than you did before. If, owing to the difficulty of the task, your original mental set proves inadequate to sustain (*b*), then a new act of will, giving rise to a new mental set, has to be forthcoming. Fortunately (*a*) is so easy that even the most "scatter-brained" of people would require but a single set

6. *W*, OR PERSISTENCE OF MOTIVE

These sets, or determining tendencies, play a very important part in our cognitive lives; and there are marked differences between one man and another with respect to them. In short, "persistence of motive" is found to play a very great part in determining a man's success or failure at *all* cognitive performances. For the fourth and last time we meet a general factor in ability. To *g*, *p* and *o*, we must add *w*, to represent the will factor in, or the effect of volition upon, cognition. In so far as a man's volitionally engendered motives to perform a given task tend habitually to persist without conscious reinforcement; in so far as, having initially willed to do so-and-so, his subsequent actions tend

to proceed smoothly and automatically; in proportion, that is, to the efficiency of his *w*, so will his *g*-*s* equipments be enabled to function to their fullest efficiency.

The person with marked *w* has, then, a big advantage in his cognitive life; and it is not difficult to understand that this trait is found in practice to be correlated with perseverance and conscientiousness, and even with trustworthiness.

Clearly, then, the effectiveness of cognition depends, in part, upon the effectiveness of the mental set which sustains it; and it is this factor *w* which represents the extent to which a person's cognitions tend to proceed efficiently without conscious intervention on his part. In a man of marked *w* a single mental set is generally adequate to carry him through a cognitive process; a renewed resolution will not normally be required. The motives he has accepted, persist. His activities proceed consistently without volitional reinforcement.

7. CONCLUSION

It seems, then, that present cognitive efficiency depends always upon these two orectic factors. On the one hand, it depends on conscious conative control; and, on the other, on the unconscious effects of volition. It follows, therefore, that we have to enunciate a LAW OF CONTROL, namely, that *the intensity of cognition can be controlled by conation and volition**.

REFERENCE

(1) For fuller discussion of this topic see *Directing Mental Energy*, chap. 10, Aveling.

* It must be added that Spearman recognizes only a LAW OF *CONATIVE* CONTROL (Cf. NP, Chap. 9, and AM, Chap. 20).

CHAPTER FOURTEEN

BASIC CONDITIONS

1. Introduction.

A : AGE

2. Effect of Age on *g*.
3. Effect of Age on the *s*'s.
4. Effect of Age on the Other Quantitative Determinants.

B : HEREDITY

i. Racial Inheritance

5. Racial Inheritance and *g*.
6. Racial Inheritance and the *s*'s.
7. Racial Inheritance and the Other Quantitative Determinants.

ii. Parental Inheritance

8. Parental Inheritance and *g*.
9. Parental Inheritance and the *s*'s.
10. Parental Inheritance and the Other Quantitative Determinants.

C : SEX

11. Sex Differences in *g*, *p*, *o* and *w*.
12. Sex Differences in the *s*'s.

D : HEALTH

13. General Bodily Condition.
14. Effects of Injury to the Brain.
15. Ill Health.
16. Basic Conditions and the Constancy of Cognitive Output.

1. INTRODUCTION

Only one further law remains to be formulated in this section ; but it must be regarded as in many ways the most fundamental of them all. We have seen that our ability, say, to learn French depends on *g* and the particular *s* for this accomplishment ; and we have also said that people vary in the amount of *g* at their disposal. We have now to

ask how it is that such individual variations occur. But this problem arises not only in connection with *g*, and, of course, with the *s*'s; it also arises when we consider the quantitative determinants of ability. We have said, for example, that people vary in the effectiveness of their mental sets. In theory, two people may start with identical *g*-*s* equipments for learning French; but if one of them has a more effective *w*, he will soon acquire an increasingly superior facility. We must also ask, then, how it is that people vary in *w*; and similarly with all the other quantitative determinants.

Although the law concerned with such problems as these may be stated quite definitely as the LAW OF BASIC CONDITIONS, (1) it must be confessed that it calls for a tremendous amount of further research, for the full scope and details of its application have by no means been exhaustively analysed yet. The law itself can be stated in the following way: *The extent to which the preceding tendencies are manifested is associated with certain basic conditions, all of which vary from person to person, and some of which vary within the same person at different times.*

The most important of these basic conditions are those of **age, heredity, health** and **sex**; and these four will be examined very briefly in turn.*

A: AGE

2. EFFECT OF AGE ON *g*

The quantity of *g* which a person has at the disposal of his *s*'s, must be regarded as increasing from zero at conception to a maximum which he attains some years after birth. Whether during the years of senility *g* decreases from this maximum or remains there, is a question which has as yet by no means been settled. On the whole present experi-

* Others, not discussed here, are those of *sleep* and *death*.

mental indications incline one to the latter, more optimistic view. A great deal of research, not all of which has recognized the extreme complexity of the problem, has been devoted to ascertaining the exact period in life at which *g* attains its greatest quantitative development. From the mass of material which has accumulated around this problem two broad principles may be deduced.

(1) It seems that for most people "the growth of *g* certainly does not continue, to any appreciable extent, after the ages of 15 or 16" (2).

(2) The length of the period of development depends somewhat upon the amount of *g* finally available, the feeble-minded tending to finish their *g*-growth rather sooner than normals, and the latter a little sooner than those of superior ability.

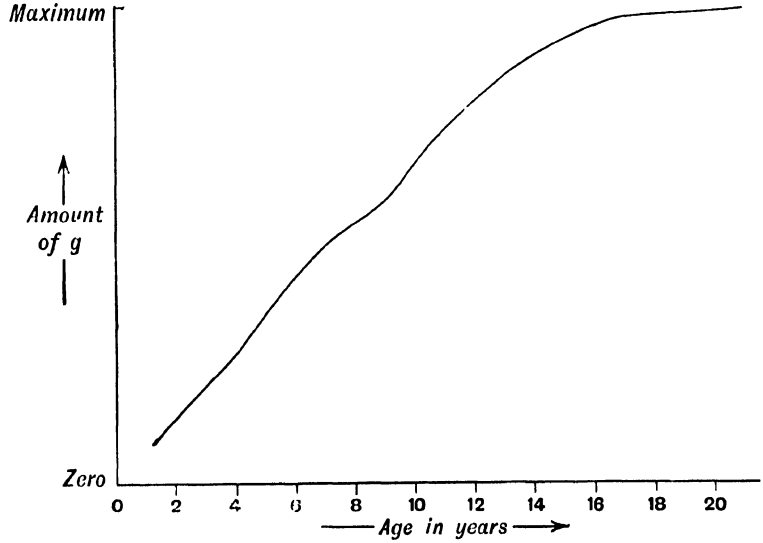


FIG. 12

It is certain that in all types the growth is very rapid indeed during the first few years of life; but that the rate of increase tends to become less and less rapid as the years go on. This retardation of the growth-rate must not be assumed to take place with perfect smoothness in the case

of any particular individual. There is, for example, evidence of a temporary slowing-down of growth at about the age of nine (Fig. 12) (3); and it is possible that if a person's *g*-curve could be plotted accurately from birth onwards it would by no means be regular.

3. EFFECT OF AGE ON THE *S*'S

Here the problem is even more complex. It is definitely established that age adversely affects the retentivity of the neural mechanisms underlying the *s*'s, and thus has a deleterious effect on both the *facilitation* and the *association* of cognitive processes. Further, it is probable that this deterioration sets in very early in life. Of the effects of age on neural *fatigability* nothing is known for certain.

To look at the problem from a rather different point of view, *s*'s of low levels may be affected by age in opposite ways, according to whether they are mainly effector or receptor in character. In so far as they are receptor they attain maturity of function very early in life, much sooner, for example, than *g*. But in so far as they are effector their development may be much more protracted, and they may, indeed, never achieve their full potentialities at all. Even a Paderewski and a Kreisler practise assiduously, and benefit from doing so.

On the other hand, *s*'s in complex cognitive processes involving ideas,* as opposed to mere sense impressions and their muscular effects, may be affected by age in highly erratic ways. In so far as they depend on information they may obviously be improved indefinitely, and that in spite of increasing loss of retentivity. But in performing a particular cognitive task one's method of procedure may be altered at any time for better or worse, new *s*'s being, as it

* Cf. p. 41; and p. 268 *et seq.*

were, substituted for the old ones. The case of Dr. Saloz (page 40) will be remembered here. In this sense improvement or deterioration may occur at any age; it all depends whether or not the new *s*'s are really more effective than the old.

4. EFFECT OF AGE ON THE OTHER QUANTITATIVE DETERMINANTS

In dealing with the effect of age on *w* it is necessary to abandon the methods of quantitative experiment for those of ordinary observation, supplemented by the clinical investigations of the several schools of psychotherapy. In common experience we find that the persistence of a man's motives may be modified for better or worse at any time of life, by self-discipline, or the loosening of self-control. In addition, psychotherapists of all persuasions achieve adjustments in their patients by which volition is rendered immeasurably more effective (4). On the other hand, nothing is known of the effects of age, if any, on *p* and *o*.

B: HEREDITY

The influence of heredity upon ability may best be examined under the two heads of *race* and *parentage*.

i. Racial inheritance

5. RACIAL INHERITANCE AND *g*

The influence of race upon *g* has been submitted to a great deal of sporadic investigation; but such work is beset with grave practical difficulties, and the conclusions must be accepted with caution. On the whole it would appear that most white races have, on the average, more *g* than black ones. Cattell, after examining the present evidence

very judiciously, says, "I think the following provisional order of racial intelligence will not be found far wrong:

1. Nordic and Jews.
2. Alpine.
3. Mongolian.
4. Mediterranean.
5. Negroes.
6. Lowest races, Australian Blacks, etc." (5)

Certainly, in England, Jewish children tend on the whole to be better equipped with *g* than non-Jewish children of the same age and similar schooling. None the less, variations between the individuals of one and the same race are immensely greater than any differences which may exist between the average levels of diverse races; the best endowed negro being, for example, very much superior to, say, the vast majority of Nordics.

6. RACIAL INHERITANCE AND THE *S*'S

Very little systematic investigation has been made of the influence of race on the *s*'s. It is sometimes asserted that primitive peoples of a hunting mode of life excel in such traits as visual and olfactory acuity when compared with white folk; but how far such differences, if they exist to a significant extent, are due to the true inheritance of a modified neural structure rather than to the effects of facilitation by practice, has yet to be determined. In any event research into the more fundamental problems of the racial inheritance of relative *fatigability* and susceptibility to the effects of *facilitation* does not yet seem to have been begun.

7. RACIAL INHERITANCE AND THE OTHER QUANTITATIVE DETERMINANTS

Nor has investigation into the equally important problems of racial differences in *p*, *o* and *w*. Teachers sometimes say

that Jewish children tend to exhibit more *w* than comparable Gentiles; but, if this is true, it is much more likely to be due to early training than to any truly inherited racial trait.

ii. Parental inheritance

The influence of familial inheritance on ability might seem to be a problem easy of solution. Unfortunately this is very far from the truth. Common observation shows that a person's abilities are more likely to resemble those of his parents and other near relatives than those of strangers selected at random. But this is not at all the real question. Is this extra conformity within a family really inherited, or may it not be due rather to the fact that all the members have shared environments resembling one another more closely than the environments of strangers usually do? That is the real problem, and it is a surprisingly difficult one to answer unequivocally.

8. PARENTAL INHERITANCE AND *g*

It seems that parental inheritance plays the more important role in the determination of *g*. None the less, the laws of its inheritance are not in the least understood, except that some forms of feeble-mindedness seem to behave as recessive Mendelian units. In families with such an hereditary taint, not every member exhibits *g*-deficiency; but those members who themselves escape, and who are apparently normal, tend to have feeble-minded offspring. It cannot, however, be said that *g* itself behaves as any yet recognized Mendelian unit, recessive or otherwise; it is only some varieties of *g*-deficiency which do so.

9. PARENTAL INHERITANCE AND THE *S*'S

Familial inheritance of *s*'s is an equally difficult and even less explored topic. Systematic investigation into their

underlying neural *facilitation* and *fatigability* has not begun. We have only chaotic, inconclusive and often contradictory observations on much more complex phenomena, such as musical talent, which certainly seems to "run in families" quite often. On the whole it would seem that environment plays a greater part than heredity in the determination of most *s*'s.

10. PARENTAL INHERITANCE AND THE OTHER QUANTITATIVE DETERMINANTS

As for p and o, reasons for anticipating that familial inheritance may be of great importance in their determination are implied in Chapter 16*; but it must be understood that this is only a guess, and not an established fact of observation.

Most likely heredity has little to do with w, which seems to depend almost wholly on the training consciously and unconsciously given and received during early childhood. The possibility that it has heritable temperamental bases must not, however, be ruled out entirely.

C: SEX

11. SEX DIFFERENCES IN g, p, o AND w

In the main, any differences with respect to g which may exist between the sexes are very slight. The most important seems to be that males tend to extremes of idiocy and genius more frequently than do females; but between the average level of g in one sex and in the other there seems never, at any age, to be any significant difference at all. There are, however, differences of another sort which can be illustrated from one of Burt's studies of reasoning power in children.

* P and o are there regarded as functions of g. Hence, in so far as familial inheritance is of importance in determining g, we may tentatively presume that it is of comparable importance in determining p and o also.

This author writes, " Girls excel in patient and persevering analysis, in attention to minutiæ and details, in jumping to presumptive conclusions, in constructing concrete hypotheses or picturing definite situations by the aid of the imagination, and, above all, in rapidly extracting the meaning of printed statements and in formulating their solutions in words " (6). On the other hand, boys were found to be more methodical, self-critical and logical; but less verbose and less suggestible than girls.

" All this ", Spearman observes, " in so far as it is not traceable to traits of character rather than of cognition, may perhaps arise from a greater tendency of the male sex to perseveration." (7) It is to be added that, so far, no sex-differences in *o* are known.

12. SEX DIFFERENCES IN THE *S*'S

The work of Burt, cited in the previous paragraph, illustrates one important sex-difference among the *s*'s. This is concerned with linguistic facility, where girls are uniformly superior to boys. The same superiority has been found by other workers in colour and tactile discrimination, and also in retentivity for prose, the last trait probably hinting at a greater *associative* capacity among girls. On the other hand, boys excel in activities, such as geometry and many mechanical operations, where spacial relations are of special importance; and also in arithmetic.

D: HEALTH

13. GENERAL BODILY CONDITION

Among children there is evidence that the more gifted in *g* tend to be physically and sexually more mature than those who are merely normal; but the latter appear to catch up in time, for among adults there is no evidence of correlation between *g* and any physical trait.

14. EFFECTS OF INJURY TO THE BRAIN

Injury to most parts of the brain has the effect of reducing the amount of *g* available; and abilities tend to be impaired in proportion as they depend upon *g* rather than upon *s*'s. As far as the latter are concerned, there appears to be a modification in *retentivity*; but this only affects recent events. It amounts to a "loss of capacity for new retentions" (8). On the other hand, injury to *certain* areas of the brain may be followed by little impoverishment of *g*, but by serious damage to some particular *s*'s, resulting, for example, in local anæsthesia, paralysis or aphasia. (Cf. page 40.)

15. ILL HEALTH

Ill health appears to affect *s*'s, but not *g*. This appears to be due to an increase in *objective neural fatigability*, and, in some cases, to an enhanced tendency towards *subjective fatigue*. On the whole, gifted children and adults tend to be freer from ailments and defects than do duller ones. It has once more to be added that investigation has hardly begun to probe into the problems of how far the other quantitative determinants of ability are affected by ill health.

16. BASIC CONDITIONS AND THE CONSTANCY OF COGNITIVE OUTPUT

It must have been noted that in this chapter no specific reference has been made to the extent to which these basic conditions of age, heredity, sex and health affect the amount that a person can cognize at a given instant or during a given period, though such questions are of obvious practical importance. But, clearly, the amount or degree of cognition at any given moment depends upon the available quantity of one's *g* at that moment, and on the present efficiency of the

particular *s* involved; and the observed associations of *g* and *s* on the one hand, with the basic conditions on the other, have been treated in this chapter as exhaustively as is at present possible. The whole of it must, therefore, be taken as referring to this problem of cognitive output in a very immediate way. The reader may, perhaps, care to think out for himself the effects of the basic condition of sleep upon the constancy of cognitive output; remembering particularly a fairly popular current view—to which he may or may not subscribe—that, while asleep, everyone dreams all the time.

REFERENCES

(1) Stated originally by Spearman as the *Law of Primordial Potencies*. Cf. NP, p. 36, and AM, p. 360.

(2) AM, p. 364.

(3) C. Burt, H. Crichton-Miller and W. A. Potts, *The Development of Mind and Character*, p. 7. (*B.B.C.*)

(4) Cf. Hadfield, *Psychology and Morals*, especially chap. 18 *et sqq.*

(5) *Psychology and Social Progress*, p. 53.

(6) *JExP*, 1919.

(7) AM, p. 391.

(8) AM, p. 397.

CHAPTER FIFTEEN

ILLUSTRATIVE

1. *G* AND *S*.
2. THE QUANTITATIVE DETERMINANTS.
   (*A*) Constant cognitive output.
   (*B*) Facilitation.
   (*C*) Inertia.
   (*D*) Fatigue.
   (*E*) Variability.
   (*F*) Conation and volition.
3. CONCLUSION.

Before passing from the observed facts of ability to theorizing about them, it would be well to discuss briefly a particular situation in which all the factors and determinants of ability are clearly apparent. Let us consider the occasion when, playing chess against an opponent whom I usually beat, I lose the game.

1. *G* AND *S*

The fact that I usually win suggests one of three things: either that I have more *g* than my opponent, or that my *s* for chess is more efficient than his, or that I have both these advantages. The *s*, of course, must be thought of as a group of connected neurones almost wholly within the brain; a group which is consistently active when I play chess, but presumably much less active when I am comparing ties in a shop, listening to *Summer Night on the River*, wondering whether I need answer that letter after all, or doing anything else whatsoever except, possibly, playing draughts.

2. THE QUANTITATIVE DETERMINANTS

The fact that I lose on this occasion may be due to an exceptional superiority on my opponent's part, to an excep-

tional inferiority on mine, or to a combination of both influences. Let us consider the second case, assuming that the victor has played only up to his usual standard. My failure to-day will then be due to a complex of the phenomena we have been discussing in Part 3; and the possible relevance of each will now be examined in turn.

(A) Constant cognitive output. It may be that *g* has been absorbed in unproductive activities. I have been studying, shall we say, a certain possible sequence of moves. But cognitive output is limited; and since I have been absorbed in these possibilities, the quite different one which my opponent had schemed has escaped me. Or, again, I may have been preoccupied with other matters entirely, my *g* activating quite different and irrelevant *s*'s; I may be expecting an unpleasant visitor, or still recovering from the effects of one, and *g* will consequently not have been devoted wholly to the chess-*s*.

(B) Facilitation. In the second place it may be that during the game a situation arose which had occurred to me yesterday, and to which I had then made the wrong response. If I did not realize at the end of yesterday's game that this particular move was the cause of my subsequent defeat, then there will be a tendency to repeat the same move to-day, at any rate if no other is particularly obvious.* As for association, that too may have played a part in my present downfall. A situation may have arisen which reminded me of some other more memorable game I had played before; and *g* may consequently have been divided between my present

* This prompts a reflection on some rather heterodox advice which is occasionally heard on the golf course; namely, to practise one's *best* strokes. This is sound doctrine when interpreted in the light of what has been said about facilitation. If your putting to-day is disastrous, although your driving and approach shots are relatively normal, then, clearly, it is better to practise them than to facilitate bad putting. Practice at the latter should be left for the day when you simply can't keep on the fairway.

occupation and my reminiscences of that occasion. Perhaps my opponent " castles " his king, and I think of the last of my opponents who did the same, and who has borrowed and kept a treasured book of mine so long that I expect never to see it again. If so, the associated emotions will certainly not improve my present performance.

(C) Inertia. Perseveration can, I suppose, hardly bring about marked temporary variations in one's talent for chess. Probably a lack of *p* is an advantage to a chess player, enabling him to contemplate first one possibility and then another with great rapidity. It is certain that the expert who plays many games " simultaneously " can hardly be a marked perseverator; he must be able to switch his *g* from one game to the next with a minimum of lag. To revert to the present hypothetical game; it may have been that the idea of a particular scheme, which later brought defeat, perseverated and so prevented my giving due consideration to another which might have been more successful.

(D) Fatigue. The possible role of fatigue in bringing about my downfall is too obvious to need extensive illustration. In particular, if the game happened to have seemed to me rather " stodgy " and pedestrian from the outset, boredom may have intervened to impair my efficiency.

(E) Variability. One would like to know rather more about the amount and duration of cognitive oscillations before dogmatizing about their possible influence upon a game of chess. But it seems possible that one might, without being in the least aware of it, arrive at the solution of a crucial problem at a moment when efficiency was at a minimum. If so, that solution might well prove less successful than a possible alternative which might have been grasped at a moment when efficiency was greater. It is worth noting that the last sentence contains one " if " and two " mights ".

(F) Conation and volition. The parts which conation and volition, or, rather, the lack of them, may have played in my downfall are fairly obvious. For any of a thousand reasons beyond the scope of a psychology of cognition, I may not have been trying hard and consistently enough, and so may have failed to make my cognitions of the problems which arose, sufficiently intense. Or it may be that at the outset I did not really want to play at all; and my "half-hearted" resolve to do so left me with a mental set quite inadequate to prevent fatigue and irrelevant associations from impairing my game.

3. CONCLUSION

This example should at least illustrate the probable complexity of any actual situation in which the success or failure of a cognitive process has to be considered. Positive contributions to success come from two sources at the most; but the sources of failure are many and diverse. The position may be summed up in the following propositions:

(1) *SUCCESS* at any cognitive task, perceptive or rational, depends on the *presence* of a sufficient supply of *g*; the *presence* of an adequate *s*; and on the *absence* of interference by any of the quantitative determinants.

(2) *FAILURE* at any cognitive task may be due to a lack of *g*; to an inadequate *s*; to interference by any of the quantitative determinants; or to any two or more of the above causes.

The presence of the two factors *g* and *s* makes for, and will secure, success in the long run; but the quantitative determinants may, on any particular occasion, play havoc with the factors, and so bring about failure in any activity, even to those who are really best equipped for it.

CHAPTER SIXTEEN

THE "ENERGY-ENGINE" HYPOTHESIS: 2

1. INTRODUCTION.
2. QUANTITATIVE DETERMINANTS AFFECTING *g*.
   - (*A*) Variability.
   - (*B*) Inertia.
   - (*C*) Conative and volitional control.
   - (*D*) Constant cognitive output.
   - (*E*) Subjective fatigue.
   - (*F*) Conclusion.
3. QUANTITATIVE DETERMINANTS AFFECTING *s*'S.
   - (*A*) Objective fatigue.
   - (*B*) Facilitation.
4. BASIC CONDITIONS.
5. NOMENCLATURE: THE THEORY OF *TWO* FACTORS.

1. INTRODUCTION

Before concluding these chapters on personal variations of talent, it will be as well to see whether the energy-engine hypothesis can be extended to cover the new phenomena we have met. It was said that *g* behaves *as if* it were a sort of undifferentiated cognitive energy, and the *s*'s *as if* they were a multitude of different cognitive mechanisms, or "engines", any of which *g* can activate (page 54). The problem now is to see whether the facts of perseveration, constant output, fatigue and the rest are compatible with this analogy.

2. QUANTITATIVE DETERMINANTS AFFECTING *g*

(A) Variability. The facts of variability suggest inevitably that one's supply of *g* tends always to oscillate slightly about its normal level. At times we have rather more cognitive energy than at others; and since the amount available to activate the *s*'s varies from moment to moment, it comes

about that our ability fluctuates too. Sometimes we can hear the watch plainly, or put a dot in every circle; sometimes not.

(B) Inertia. Perseveration points to a possible lack of fluidity in *g*. When the latter is transferred from one *s* to another, there tends always to be a brief phase during which the new activity cannot be performed at maximum efficiency owing to the perseveration of the old. It seems as though cognitive energy can only drain gradually, not instantaneously, from one *s* to another; as though *g* were slightly viscous.

(C) Conative and volitional control. *How* cognitive energy can be subject to conative and volitional control is a problem to which the most daring speculator would scarcely venture to suggest an answer. It is certain that no answer will be attempted here. One can only say, first, that *g* behaves *as if* it could be concentrated or focussed by present conative effort, and so used to heighten awareness within a narrower field. Secondly, *g* seems to be, if we may coin the word, *teledirigible*.* By volition, it may be directed into a particular *s*; to remain there indefinitely, without further conscious restraint, until its task is accomplished.

(D) Constant cognitive output. There seems little difficulty in accounting for the tendency to constancy of cognitive output in terms of a *g*-energy which may be utilized by this *s*-mechanism or that. In so far as the energy supply remains constant, so will its output of actual cognitive awareness. Just as a certain supply of electrical energy may be made either to work a particular motor for a definite time, or to give an equivalent amount of light or heat, so one's supply of *g*-energy may activate one *s*, thus producing a

* *Tele* as in *tele*phone, not as in *tele*ology. (I.e., from τηλε = *far*, not from τελε = *end*.)

certain amount of cognition of one sort, or another *s*, producing an equivalent amount of a different sort of cognition. Experimentation into the exact quantitative equivalence of different varieties of cognition is obviously beset with very great practical difficulties; but it has been begun, and so far the results support what is said above (1).

(E) Subjective fatigue. Subjective fatigue, as we have said, seems to be in itself an orectic rather than a cognitive phenomenon. Its effects on *g* are indirect, for it impairs cognition by inhibiting conative control and by weakening the effects of volition.

(F) Conclusion. *G*, then, behaves *as if* it were a somewhat viscous [*p*-phenomenon] energy which is supplied to the cognitive mechanisms [*s*'s] in a slightly unsteady fashion [constant output $+o$] and whose distribution among the *s*'s can be regulated by conation or volition.

3. QUANTITATIVE DETERMINANTS AFFECTING *S*'S

(A) Objective fatigue. Objective fatigue seems to be caused by the formation of toxic products of neural activity. In the first place, this brings about specific fatigue by affecting those neurone groups, or *s*'s, which, through having been themselves active, have produced the toxins. But, in the second place, the latter are conveyed by the blood stream throughout the nervous system; and they consequently have a deleterious effect upon all other *s*'s as well.

(B) Facilitation. Facilitation, which must also be taken to affect the *s*'s and not *g*, may be concerned with the synapses which separate one neurone from the next. It is strictly incorrect to speak of *a* nervous impulse, say, from the eye through the brain to a muscle; one should speak rather of a *succession* of nervous impulses. Each neurone has its own impulse which ceases at its extremity, but which

excites or induces a new impulse in the neurone on the other side of the *synapse* which separates them. These synapses are said to present resistance to the passage of inductive effects across them; and it is held that this resistance becomes reduced by repeated use of the synapse, as though a smooth and well trodden path were formed where previously the way was difficult.*

4. BASIC CONDITIONS

The effects of age, heredity, sex and health on *g* and the *s*'s have already been discussed as fully as possible; and reflection will show that they present no difficulties to the energy-engine hypothesis.

5. NOMENCLATURE: THE THEORY OF *TWO* FACTORS

It is hoped that the present chapter may have done something to clear up any difficulty the reader may have experienced over the use of the word "factor". We may repeat that our concern is with a theory of *two* factors, general and specific, *g* and *s*. But we have also spoken (for example, on page 81) of *o*, *w*, *p*, and possibly *c*, as being "general factors". The present writer deprecates this equivocality,

* One view of this matter of synaptic resistance may be summarized as follows: The voltage of the minimum electric current which, when applied to a nerve indefinitely, will provoke it to activity, is termed the *rheobase* of that nerve. Currents of less than the rheobasic voltage will not excite a nerve, however long they may be applied. As the voltage of the stimulating current is increased above that of the rheobase, so the time required for the nervous impulse to be aroused becomes progressively less. The length of time taken for a nerve to react to twice the rheobasic stimulus is termed the *chronaxie* of that nerve. Chronaxie varies widely from nerve to nerve within the same organism. It seems likely (*a*) that a neurone excites impulses in other neurones with which it has synaptic contact in proportion as these are *iso*chronic with it; and (*b*) that neurones which, initially, are not perfectly isochronic, tend to become more nearly so whenever they are brought into functional linkage.

and tentatively suggests an alternative nomenclature. *O*, *w*, and *p* are certainly " general " since they affect all cognitive operations; but they are " factors " in only a secondary sense. They seem to affect all such operations *in*directly—by *first* affecting the general factor, *g*. The alternative here suggested is to speak of *g* and *s* only as the " factors "; and of *o*, *w* and *p* as the " general *determinants* ", of ability.

REFERENCE

(1) AM. p. 120 *et seq.*

PART FOUR

THE BIRTH AND GROWTH OF KNOWLEDGE

THE PROBLEMS

We have now to face a group of new and fundamental problems. So far we have considered an energy which operates through a multitude of engines; and we have said that the outcome of this is more or less successful cognitive activity. On one occasion this activity takes the form of making a move at chess. On another occasion we recognize a face or a tune or the meaning of a phrase in our own or another language; at another time we observe the traffic signal change from green to yellow; and so on. It all depends on what particular s *it is that* g *happens to be activating at the time. Now we must examine these gross products of cognitive activity and subject them to a more subtle analysis, for it would appear on the surface that making a move at chess and recognizing a tune have little in common.*

We shall inquire, then, in what manner it is that cognition takes place; and also whether cognitions differ fundamentally among themselves. Using the terms with which the reader of the earlier Parts of this work is already familiar, we may ask the following questions: WHEN, UNDER THE RESTRAINT OF THE QUANTITATIVE DETERMINANTS, *g* ACTIVATES THE *s*'S, DOES IT BRING ABOUT ONE INVARIABLE RESULT—COGNITION OF A UNIFORM NATURE? OR DO COGNITIVE EXPERIENCES DIFFER IN ANY IMPORTANT WAYS AMONG THEMSELVES? AND, IF SO, IN WHAT WAYS?

Further, since my present cognition, say, of a passage of French, depends on a highly complex system of inter-related previous cognitions, other problems arise. We shall have to find out not only how it is that elementary cognitive experiences come into being, but also HOW THEY ACCUMULATE, BECOME WELDED TOGETHER, REMAIN TO PLAY A PART IN MY PRESENT COGNITIVE ACTS, AND FINALLY DISAPPEAR FROM AWARENESS ALTOGETHER. *As a matter of fact, these latter questions will be dealt with first, for they are the less difficult, and their solution can be expressed almost entirely in the terms with which the reader of the earlier Parts of this work is already quite familiar.*

Clearly there is only one fundamental way of finding the answers to such questions as these. We must employ the method of introspection, observing the history and characteristics of cognitive experiences which are actually in process of happening to us here and now. This has the advantage that the validity of the answers proposed will be open to verification by the reader who cares to undertake the necessary self-observation; no elaborate statistical technique or experimental facilities will be required.

CHAPTER SEVENTEEN

CLEARNESS VARIATION AND REPRODUCTION

1. The Phenomena.
   (*A*) Clearness variation.
   (*B*) Reproduction.
2. Clearness Variation, Reproduction, and the Growth of Knowledge.
3. Clearness Variation.
   (*A*) Clearness variation and " attention ".
   (*B*) The role of the quantitative determinants.
   (*C*) Conclusion.
4. Reproduction.
   (*A*) The role of retentivity.
   (*B*) Further problems of reproduction.
      i. The role of association.
      ii. Pastness.
5. Conclusion.

1. THE PHENOMENA

(A) Clearness variation. The first point to notice is that *items in awareness are constantly changing in clearness.* A few moments ago you were clearly aware of the meaning of a word or of a phrase on the previous page. Now that awareness has faded, and has been superseded by entirely new cognitions. If you care to exercise conative control you can, here and now, become clearly aware of the pressure of your back against the chair, or of this book against your fingers as you hold it ; but normally these experiences are of zero clarity, you are not conscious of them at all. Variations in the clarity of cognitive items, ranging from almost obsessive vividness to the point at which they disappear altogether (1), are, then, of constant occurrence.

(B) Reproduction. But when an item fades completely from awareness and is replaced by another, the latter may

consist either of a completely new item of cognition or of the reproduction of a former item. An example of a completely new item would occur in listening for the first time to some music of Berg or Bartok, when you would hear sounds you had certainly never heard before. Examples of the replacement of present cognitive items by others reproduced from one's own past experience are too frequent to require illustration; for it is self-evident that *many items become cognized in a manner which postulates their having been cognized before.*

2. CLEARNESS VARIATION, REPRODUCTION, AND THE GROWTH OF KNOWLEDGE

Before the phenomena of clearness variation and reproduction are analysed in detail it would be well to point out the reason for discussing them at all under the heading of the *birth and growth* of knowledge. To consider phenomena of the second kind first: it is plain that if reproduction of what had once taken place in awareness never occurred, it would be impossible for knowledge to grow at all. Cognition would always be of a meaningless present; for even though a former experience happened now and then to be repeated, we should not even recognize it as a repetition. Experience could hardly be thought of as growing if it were incessantly starting from a new zero.

Similarly, clearness variation is of very great importance in any discussion of the growth of knowledge. We have already seen that cognitive output tends to be constant in quantity. But if it were not for variations in the clearness of present cognitive items, it is self-evident that cognitive output would be constant in quality as well. If a child's first vivid awareness of light or warmth, of pain or hunger, never faded, it is clear that knowledge could not grow at all.

The opportunity afforded by the fading of one experience for the cognition of others lies at the root of the whole problem of the growth of knowledge. An item cannot become knowledge until it has been clearly cognized; and this cannot happen until the clearness of previous items has diminished to zero.

Further, a moment's reflection will show that clearness variation plays an even more direct role in the growth of knowledge. We speak of recollections, and even of new notions, as "coming into mind". But, to "come into mind" and to grow clearer seem really to be one and the same. It will be seen shortly that recollections may best be thought of as always subconsciously present, and as becoming consciously present when made sufficiently clearer;* and later on a similar phenomenon will be found to characterize the acquisition of new ideas.† In this sense clearness variation is of the very essence of cognitive growth.

3. CLEARNESS VARIATION

(A) Clearness variation and "attention". The problem which arises at once is whether the phenomena of clearness variation are to be regarded as among the fundamental "givens" of psychology (like *g*, *s* and the quantitative determinants) or whether they can be accounted for as the effects of other simpler processes. The first alternative is the one adopted in popular usage, and often in technical literature as well. A special faculty, or mental power, of *attention* is postulated; and it is held that items become more clearly cognized when we "attend" to them either deliberately or because they themselves compel our "attention".

(B) The role of the quantitative determinants. The second

* P. 127 *et seq.*, and p. 211 *et seq.* † P. 195 *et seq.*

alternative, however, seems much the more satisfactory; for the quantitative determinants themselves are sufficient to account for all variations in cognitive clearness. In the first place *o*-phenomena may obviously play a very important part; the experiment with the watch (page 93) will be remembered in this connection. So may *p*, for the clarity of one's present perceptions will be marred by the perseveration of a previous one. By conative control we can, as we saw, augment or diminish the clearness of any cognition; and volitional control, too, has the same effect. Fatigue of all kinds tends to reduce clarity; we complain, for example, of being " too tired to concentrate ". Facilitation of a particular item tends to enhance its clearness; and association of other items to reduce it. Constancy of cognitive output, too, plays a very important part; for, as one item diminishes in clarity, that of another is automatically enhanced; and vice versa.

(C) Conclusion. It seems, then, that the phenomena of clearness variation, important though they certainly are, are not fundamental. That is, they must be regarded as manifestations of the quantitative determinants, and not as demanding some such *ad hoc* mental power as " attention " to account for them.

4. REPRODUCTION

(A) The role of retentivity. We have seen already that bygone experiences can re-enter awareness. Now we must inquire how it is that, despite their being past, they are yet in some manner present. In what way is it that this morning's experience of a letter still lives on? If it did not do so, it could hardly affect my mental processes this afternoon. But it does affect them; for although the letter has been lying untouched and unseen in my pocket ever since I read

it at breakfast, I have just been thinking about its contents, and have decided to stop typing these lines and to answer it at once.

At rock bottom this problem is one of retention : we are asking how it is that past experiences are retained for subsequent revivification. Now retentivity has been dealt with already under the two headings of facilitation and perseveration (chaps. 9 and 10). Which of these two processes is the more important as the basis for subsequent reproduction, or whether they are equally important, it is impossible to say at present. Until very recently it was asserted dogmatically on all sides that the retentive property of the neurones was the basis of the revival of experience ; but this is purely a deduction grounded on somewhat dubious physiological theorizing rather than on unimpeachable observation. Introspection will show that the actual recall of a past experience takes the form of an inward observation, as if one were merely finding and making tremendously clearer something already on the threshold of consciousness, and only waiting to be noticed before crossing it. This being so, it follows that perseveration suggests itself as a very potent agent in the retention of the experience. It would seem as though the latter had never really disappeared at all, but had perseverated, or lingered on, too faintly for one to be aware of it, but none the less waiting there on the threshold of awareness all the time. " Everyone, on this view ", Spearman says, " perpetually carries about with him a comprehensive, though subconscious, presentation of his whole past experience " (2).

Perhaps both facilitation and perseveration play a part in the retention of experience ; if so, which of the two is the more influential from the point of view of subsequent reproduction matters little to us here. Whichever of its two mech-

anisms may be predominant, retentivity remains among the fundamental " givens " of the psychology of cognition ; and it is the fact, rather than any theory about it, which is of importance here.

The basis of reproduction, then, is the fact that experiences which have occurred before are still really present ; despite their pastness they have been retained, and so may re-enter awareness. But this can only occur when the intensity of a present item of experience diminishes, thus making it possible for the intensity of the retained item to increase from zero to that of full cognition. The law of constancy of output will be remembered in this connection, and also the process of clearness variation.

(B) Further problems of reproduction.

(*I*) *THE ROLE OF ASSOCIATION.* Now we must inquire how it is that, on any particular present occasion, it is one experience rather than another which is revived. The traditional answer is that the selective agency among myriads of past experiences is that of association (chap. 9 (B)). I look at a photograph on the wall ; and, although I am still " looking " at it, my awareness of it fades, and is replaced by recollections of the person it depicts, and not by recollections, say, of an incident of an hour ago. For me the person and the photograph are intimately associated ; the photograph and the incident are not. We shall, in the main, accept this view ; although some details of it will be criticized later.*

(*II*) *PASTNESS.* We described the phenomena of reproduction as the cognizing of something in a manner which forced us to conclude that we were *re*-cognizing a former item of awareness rather than experiencing the initial cognition of an entirely new one. This raises the question of the nature

* P. 163 *et seq.*

of this taint of pastness. So far we have only discussed how it is that a past experience can reappear in present awareness; we have not inquired how it is that, when it does so, we know it to have emerged from the past. Someone asks me which of the English Lakes I recommend for a holiday. I think of several in turn, reproducing and reviewing one by one a few from among those of my experiences of them which have been most vividly retained. But I do not confuse these reproduced cognitions with my present ones, say, of the questioner himself and of the city street in which we are talking. The reproductions obviously and indelibly bear the stamp of their own pastness. The explanation of this fact cannot be given wholly in terms of the quantitative determinants; and will have, therefore, to be postponed. The reader must keep the problem in mind until Chapter 25.

5. CONCLUSION

It appears, then, that these two important phenomena of clearness variation and reproduction are not fundamental but derived. Putting it another way, we may say that, given the fundamental laws of cognition, the phenomena of clearness variation and reproduction must necessarily occur. Both processes are solely the products of the quantitative determinants; although the recognition of reproducts as such is a function of another fundamental process which has yet to be discussed. It follows that we can hardly postulate "laws" of clearness variation and reproduction in the way in which we have been able to postulate, among others, laws of *g*, inertia and fatigue. We must rather regard the two phenomena discussed in the present chapter as being inevitable corollaries of other fundamental laws of cognition.

REFERENCES

(1) Spearman originally treated the phenomenon of DISPARITION apart from that of CLEARNESS VARIATION (Cf. NP, pp. 138-139). It is now regarded as being but the limiting case of the latter.

(2) NP, p. 325.

CHAPTER EIGHTEEN

THE PRE-HISTORY OF NEW COGNITIONS

1. The Problem Re-stated.
2. Non-mental Prerequisites of Cognition.
3. The Limits of the Psychological Problem.
4. The Dawn of Awareness.
5. Summary.

1. THE PROBLEM RE-STATED

We may now deal with the other problem of the growth of cognition. It will be remembered that this is concerned with the acquisition of new items of knowledge, as distinct from clearness variations of present items and the reproduction of old ones. Putting it quite simply we may ask: By what process or processes do we pass from a state of ignorance of a thing to a state of knowing something about it? And also: In what form or forms does new knowledge first come into existence? We have seen, of course, that *g* and the *s*'s are ultimately responsible; now we are asking how they produce their results, and what these results are in the ultimate analysis.

2. NON-MENTAL PREREQUISITES OF COGNITION

It is a useful preliminary to select some particular "thing" as an object for experimental cognition; then we can start by referring our questions to this particular instance. The universality of the answers can be checked by further experiments.

Let us take a picture hanging on the wall as the starting-point. What may be termed the "pre-history" of the visual

perception of such an object is too well known to require detailed description. Physicist and physiologist join forces, and between them distinguish a long sequence of events (Fig. 13) which must inevitably occur before we can become aware of its presence.

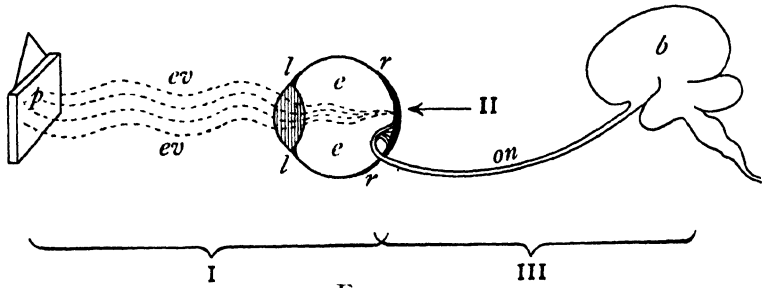


FIG. 13

p	Picture	I	Physical stages
ev	Ether vibrations	II	Chemical stage
e-e	Eye	III	Neural stages
l-l	Lens		
r-r	Retina		
on	Optic nerve		
b	Brain		

In the first place ether vibrations of a definite type must be falling upon the picture, and must be reflected by it upon at least one of two small areas of our body.* We shall not perceive the picture if the room is in darkness; nor if something stands between it and ourselves; nor even if we have our backs turned to it, or our eyes shut. The vibrations must reach the eyes, where they are focussed by the lens upon the retina at the back. When this happens it is followed by chemical changes in the pigment cells which lie on the surface of the retina, and in the visual purple, a liquid which bathes this surface. These chemical changes are followed in turn by neural changes which begin in the nerves of which the sensitive ends are buried in the pigment cells, and these neural changes or impulses pass from neurone to neurone along the optic nerve and finally reach the brain.

* Alternatively, the picture must be emitting radiations of some kind.

3. THE LIMITS OF THE PSYCHOLOGICAL PROBLEM

Not until all these events have taken place can the final stage of cognition occur; and it is, indeed, not until this point that the problem of cognition passes into the realm which the psychologist claims wholly as his own. After reaching the last stage depicted in Fig. 13, a developing experience makes the completely mysterious transition from the material to the mental mode of existence. Hitherto it has existed as an etheric, a chemical, and a neural process. Now it becomes a mental one; something so totally different that not only scientific investigation, but also philosophic speculation, is baffled when it seeks to discover or even imagine what manner of transition this can be. In Huxley's words, "There is no doubt that a molecular change in some part of the cerebral substance is an indispensable antecedent to every phenomenon of consciousness. . . . But supposing we get so far as to be able to prove that the irritation of a particular fragment of cerebral substance gives rise to a particular state of consciousness, the reason of the connection between the molecular disturbance and the psychical phenomenon appears to be out of the reach, not only of our means of investigation, but even of our powers of conception" (1).

But the psychologist really takes his stand on the other side of this gap; and his professional interest in a developing experience only begins after the latter has made its leap from the antecedent world of physical vibrations, chemical changes, and neural processes. His first professional question must be: In what form does an experience first enter his own special territory? Thus, leaving the earliest phases to the physical scientists and the physiologists, and the transitional phase to the philosophers and metaphysicians, we may address ourselves to this new and wholly psychological problem.

4. THE DAWN OF AWARENESS

The answer is that introspection into the growth of experience shows that this initial phase is merely that of an indeterminate mental state which we passively live, suffer, or undergo. Such a state is termed a *sentience*; that is, one having no characteristic foretelling the type of experience into which it will evolve during the subsequent stages of cognition. This initial phase is normally so fleeting that it passes unnoticed; but it can occasionally be detected by accident, and can also be detected under suitable experimental conditions. Just occasionally, when being awakened by a strong stimulus, there is a brief moment of awareness of experience *as such*. It is only later that the stimulus gathers meaning, and we know that the previously unanalysable experience was that of toothache, of a bright light, of thunder, or of cramp. In a state of light hypnosis, too, it is possible vaguely to experience a faint stimulus without being able to tell whether that experience is a visual, an auditory or an organic one.

5. SUMMARY

We may conclude, then, that cognitive experiences pass through four phases, of which full awareness is but the last.

(1) A cognition is, as it were, conceived in the physical world by purely physical and chemical processes.

(2) Then it is mysteriously transferred to the womb of mentality.

(3) Here it has a period of gestation as a mere *sentience* or *lived experience.*

(4) Finally it is born into consciousness as a fully-fledged cognition.

But it is only to the third, or embryonic, phase of complete indeterminateness that we have traced experiences so far.

Summing things up in the form of a PSYCHO-PHYSICAL LAW, we may say that *neural excitation tends to be followed by sentience, that is, by the "living" of an experience.**

REFERENCE

(1) *Lessons in Elementary Physiology*, p. 526, T. H. Huxley.

* This is not included in any of Spearman's own lists of his "qualitative principles" which do not deal with the pre-mental phases of cognitive growth.

CHAPTER NINETEEN

THE APPREHENSION OF EXPERIENCE

1. Sensation and its Characters.
   - (*A*) Quality.
   - (*B*) Quantity.
   - (*C*) Spaciality.
   - (*D*) Temporality.
2. Cognitive Processes.
3. Hedonic Feelings.
4. Conative Activities.
5. Acts of Volition.
6. The Ego.
7. A Note on Emotional States.
8. "Immediate" Awareness.
9. The *Tendency* towards Cognition.

The effect of the processes depicted in Fig. 13 is to give rise to a lived experience, that is, to sentience; and, starting from that boundary post, we can begin further explorations in territory that is wholly mental. Although lived experience is not perception, it is, as we have seen, something prior which may evolve into actual perception; and it is here that the first purely psychological process operates. There are three of these processes, and the laws which describe them are comparable with Newton's three fundamental laws of motion which describe the basic phenomena of dynamics. The first, the Law of the Apprehension of Experience, states that *any lived experience tends to be followed by an immediate awareness of its characters and of its experiencer.* We have already seen what is meant by "living" an experience, so now we must see what different sorts of experience can be discovered in ourselves; and what is meant by their having characters.

1. SENSATION AND ITS CHARACTERS

The most obvious sort of experience to become a part of human knowledge is that which the psychologist calls sensory experience; that is, *sensation*, in its strict meaning of an experience obtained through a sense-organ. There are sense-organs of five obviously different kinds, and some others as well; and these, between them, give rise to no fewer than the thirteen different sorts of sensation to be described shortly. Our first psychological law states that when a sensory experience of one of these twelve possible kinds is "lived", awareness of the characters of that experience tends to follow.

Now, a sensory experience, when it comes to full awareness, has the four characters of quality, quantity, spaciality and temporality; and, for simplicity, we will deal with that of *quality* before going any further.

(A) Quality. The *quality* of an experience is that which distinguishes it in introspection from other experiences received through the same sense-organ, or through others. Thus among the chromatic, or coloured experiences which a person of normal vision can cognize, there are some two hundred distinguishable qualities, ranging from violet at one end of the visual spectrum, through blue, green, yellow and orange, to red at the other end. Achromatic, or non-coloured, experiences have but two qualities; black and white. An assortment of greys differ not in quality, but in quantity; some contain more black-quality, and some more white-quality, than others. The quality of an auditory experience may be as "low" or "deep" as that of an organ pipe sixty-four feet long; on the other hand it may be as "shrill" as that of a bat's squeak. Between these two extremes some ten thousand or more different qualities of pitch are normally

distinguishable. So it is with other sense experiences, as is shown in sufficient detail in the following Table.

Organ	SENSORY EXPERIENCE		No. of Distinguishable Qualities.
	Common Name	Technical Term	
1. Eyes	1. Colour 2. Black-white	Visual { Chromatic Achromatic	200 + 2
2. Ears	3. Noise 4. Tone	Auditory	600 + 10,000 +
3. Parts of tongue and soft palate	5. Taste	Gustatory	4 or 5
4. Nose	6. Smell	Olfactory	500 +
5. Sensitive points scattered on the surface of the skin	7. Heat 8. Cold 9. Pain 10. Pressure	 Algesic Tactile	1 1 1 1
6. Sensitive points within the internal organs	11. Internal	Visceral	12 +
7. Sensitive points in muscles, joints and tendons	12. Movement	Kinæsthetic	1
8. Semi-circular canals	13. Posture	Orientation	?

(B) Quantity. The second character which every sensory experience possesses, and of which we may become aware by virtue of this tendency for lived experiences to become fully cognized, is its *quantity* or intensity. That is to say, one auditory experience may be louder than another of exactly the same quality; the same colour may be experienced as having different degrees of intensity; the same odour or

taste may be strong or weak; while any tactile cognition invariably has some intensity, be it great or small.

(C) Spaciality. The third of these characters is that of *spaciality*. Every cognized experience brings with it, as part of itself, the answer to the question *Where?* It is impossible to experience a colour which has no position, or one which is devoid of extension. It may be hard to locate the origin of a sound correctly; but none the less the experience has the appearance of coming from *there*, even if "there" seems to be just vaguely "all around", or even "inside the head". Similarly with tastes, odours, and indeed with all sensory experiences; they all have some character of position, although in some, particularly of the visceral sort, the localization is often very vague, and even inaccurate. We complain, for example, of feeling ill "all over".

(D) Temporality. Lastly, the fourth character of a sensory experience is its *temporality*. Briefly, our cognitions inevitably have the character of happening to us *now*, and of having some *duration*, however brief.

So much, then, for sensory experiences. They may be introduced through bodily organs of five obviously different sorts; the eye, the ear, the nose, the mouth, and the surface of the skin; and in addition there are the inconspicuous semi-circular canals, and the sensitive spots within the body. The experiences themselves may be of thirteen different kinds; colour, black-whiteness, noise, tone, taste, smell, heat, cold, pain, pressure, kinæsthetic, postural and visceral. Each has a certain quality, a certain intensity, and a certain location both in space and in time; all of which characterize it when it passes from the state of being merely lived to that of being fully cognized.

2. COGNITIVE PROCESSES

A second group of experiences through which we live, and of which we tend to become aware when we do so, is that of the cognitive processes themselves. We constantly employ verbs to describe active experiences which we are undergoing at the moment. Such are the processes of knowing, understanding, noticing, comprehending, conceiving, observing, detecting and the like. We say, " I *notice* that the weather is warmer ", or, " I *see* that it has started to rain " ; and the cognitive acts of *seeing* and *noticing* may clearly be parts of the cognized experience. It must be possible to be aware of the acts of knowing and seeing, otherwise the fact of having performed them could never be communicated to others ; we should only be able to communicate the results. That is to say ; when these cognitive processes take place they tend to make us aware not only of the knowledge to which they give rise, but also of their actual taking place. We see ; we hear ; we taste and smell things ; we feel hot or cold, pressure, pain, movement and visceral states : and not only do we suffer all these cognitive experiences, but we may become aware of the processes by which we do so. Not only can we know, but we can know that we know. This probably is one of the more striking ways in which human mental life differs from that of other animals.

3. HEDONIC FEELINGS

Hedonism is the name of that philosophy which holds that personal pleasure is the sole end or aim of existence. The hedonic feelings then are those of pleasure and of its opposite, unpleasure ; for we shall keep the term " pain " for the ninth sort of sensory experience listed in the Table on page 138.

A feeling of pleasure or unpleasure accompanies all mental

activity, forming an ever-changing background to consciousness. It is impossible to have any experience at all, sensory or otherwise, which is so purely cognitive that it has no feeling-tone, pleasurable or unpleasurable. It must be noted that the feeling-tone which accompanies, say, an experience of red is not a fifth character of that experience. It is something which is contributed to, rather than by, that experience. The same red may, for example, excite at one time a pleasurable and at another time an unpleasurable feeling-tone. That would depend wholly upon things which have nothing to do with the experience itself; for example, on bodily health, and on such orectic factors as the desire to experience or to avoid it at just that moment.

This group of pleasure-unpleasure feelings, then, forms a third kind of lived experience; and, as with the first two kinds, they tend to evoke an immediate awareness of their characters. These are the same four; the cognized experience has obviously the *quality* of pleasure-unpleasure; and *intensity* of some degree or other; and, if we bother to look for them, localizations in *space* and in *time*, for they are always experiences which are happening to us here and now. (Cf. page 9.)

4. CONATIVE ACTIVITIES

The fourth group of lived experiences which may become known consists of what we have already termed conative activities. It was said (page 9) that we should regard a conscious state as being conative in so far as it had the active character of conscious striving rather than the more passive characters of knowing and feeling. In ordinary life these states are well known, and are described in a variety of ways, of which the following are among the more common:

Striving, endeavouring, trying.

Looking for, seeking for, searching mentally.

Mental effort, mental strain, mental tension.
Alertness, concentration, directing attention.
Feelings of difficulty, or of mental impotence.(1)

These, too, are experiences through which we live, and whose characters tend to become known to us when we do so. These characters, though similar in name to those we have noted before, yet mark them off from all other types of conscious experience whatsoever. The *quality* which is distinctly theirs may be termed that of purposive self-effortfulness; in *intensity* they may be strong or weak; and they occur to us *here* and *now*.

5. ACTS OF VOLITION

Differing from the last group, though traditionally confused with them, are volitional experiences, or acts of will. Here there is no effort, no prolonged striving. There is rather a mental attitude, lasting but a moment, which sometimes initiates and sometimes concludes a train of conative activity, but which can easily be distinguished from the latter in introspection. We usually describe these states of volitional consciousness as either a decision, a choice, an acceptance or a determination; and the mental attitude which is their characteristic *quality* can best be termed a fiat, that is, the attitude represented by the phrase, *Let it be so*! These voluntary acts, then, constitute the fifth sort of lived experience of which we tend to become aware. They, too, can vary in *intensity*; they have always a prominent quality of *nowness*; and, if we care to look for it, one also of *hereness*.

6. THE EGO

Lastly, underlying each of the five other sorts of lived experience which have been discussed in this chapter, there

is a sixth variety. This is the awareness one tends to have at all times of one's own self, or ego, as the unchanging foundation of, or agent in, experience. We say, "*I* am warm", "*I* know it", "*I* enjoy this", "*I* am trying", and "*I* will begin"; recording the facts that sensory, cognitive, hedonic, conative and volitional experiences, respectively, have crossed the threshold of awareness, and have become a new part of our knowledge. The point to be noted here is that the notion of *self*, as represented by the word *I*, may be cognized together with each of these different experiences. In each of them the *ego* may play a part; either as something to which they are happening, which is its role in the first three examples; or as something which is rather the cause of their happening, as in conative and volitional experiences. Thus it is that the first psychological law has been formulated so as to include this knowledge of our own ego. We said that any lived experience tends to be followed by an immediate awareness of its characters *and of its experiencer*, thus making room for this immediate *self*-knowledge which we tend to have at all times.

7. A NOTE ON EMOTIONAL STATES

It may seem at first that emotional states form a seventh variety of experience which comes to awareness by this process of immediate apprehension; and complex emotions, such as admiration and awe, no less than simpler ones like fear, rage and disgust (Cf. chap. 2) are certainly cognized in this way. It would seem, however, that such feelings are analysable into simpler elements which have been noted already, namely, into visceral sensations and hedonic feelings; and consequently they do not require discussion here under a separate heading.

Now we have catalogued all the different kinds of experience which may advance beyond the stage of being merely lived to that of being fully cognized with all their characters; but before turning to the next topic we must examine the statement of the first law more closely. There are two points in this statement which need discussion now, since both arise again in the formulation of the two remaining laws.

8. "IMMEDIATE" AWARENESS

It was said that lived experiences tend to be followed *immediately* by awareness of their characters and of their experiencer. Now, in this context, "immediately" does not mean "instantaneously", but merely "without any mediating or intervening process". This will be better understood by reference back to Fig. 13 (page 132). Between a material thing and awareness of it there are several intermediate processes; that is, cognition can never be "immediate", but is always "mediated" by the ether, by highly complicated chemical processes in the retina, by the receptor neurones, and by neural processes within the brain itself. These occurrences mediate between the physical thing and the sentience or lived experience of it. But the first law states the fact that the further transition from lived to cognized experience, from sentience to sensation, if it takes place at all, is an *im*mediate one; there are no mediating stages in this transition.

9. THE *TENDENCY* TOWARDS COGNITION

That brings us to the last point: *if the transition takes place at all.* It must be stressed that this law describes only a *tendency*, and not an inevitable sequence of events. To take the first kind of lived experience, the sensory kind; it is certain that very much of it is never fully cognized at all.

We have seen this already (page 123) in the case of tactile experiences, many of which do not normally pass from the state of being merely lived to that of being fully cognized. The words "contingent" and "necessary" are useful in this connection. Apprehension of a lived experience is only contingent; it may or may not happen. Whether it occurs or not is settled by the quantitative determinants. Fatigue, for example, may prevent a particular cognition from taking place; so may the perseveration of a former; or the lack of conative control. In particular, facilitation of a sequence of events may result in non-cognition of some of them. This is especially true of the experience of one's own ego. Except in true fiats of volition one is seldom conscious of one's own self. When one is the recipient of impressions, or when one instigates and sustains a train of conative activity, the emphasis is normally on the impression itself, or on the changing phases of the conative process, rather than on the self which underlies both. None the less, a brief act of introspection enables one to become, as it were, self-conscious at once. The experience of the ego is constantly being lived; and the tendency for it to become a part of one's present knowledge may at any moment be realized.

REFERENCE

(1) List adapted from *An Experimental Study of the Mental Processes involved in Judgment*; B. P. Stevanović, BJP, PM, 12.

CHAPTER TWENTY

THE EDUCTION OF RELATIONS

1. The Second Psychological Law.
2. The *Tendency* towards Relation Eduction.
3. Implicit and Explicit Relation Eduction.
4. The Importance of Spacial Relations.
   (*A*) Visual symbols.
   (*B*) Words and their meanings.
   (*C*) Pictures.
   (*D*) The "Muller-Lyer" illusion.
5. Confluence.
6. Relations and Melody.
7. Relations in Animal Psychology.
   (*A*) Mammals.
      i. Rats.
      ii. Dogs.
   (*B*) Birds.
      i. Hens.
      ii. Jays.
   (*C*) Insects.
8. Conclusion.
9. Addendum: On Association.
   (*A*) The mechanism of association.
   (*B*) Illustrative.
   (*C*) Conclusion.

1. THE SECOND PSYCHOLOGICAL LAW

We must now consider the second of the ways in which we can pass from ignorance to knowledge. This process may be described as the Law of the Eduction of Relations; namely, that *awareness of any two or more items tends to be followed immediately by awareness of any relations which hold between them.* Here discussion may be briefer, for we have only to ask what items can possibly enter awareness. This question has already been answered in part. It has been shown in the previous chapter that items of six different

kinds (sensory, hedonic, conative and volitional experiences, cognitive acts, and the ego) may be apprehended by virtue of the first process alone. To these must be added two further kinds; namely, relations and correlates, the products of the second and third laws, respectively. This second law states, then, that an awareness of relation tends to be educed, or drawn out, from our awareness of two or more items of any of these eight kinds.

2. THE *TENDENCY* TO RELATION EDUCTION

It must be stressed that this law, like the first one, describes only a tendency; and that normally one does not actually educe, or draw out into awareness, all the relations which hold between items in consciousness.* Consider, for example, the two items of Fig. 14. Among other relations the following could be educed between the various characters apprehended by the first process alone.

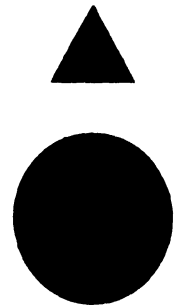


FIG. 14

VERTICALITY, between the spacial characters of the items.
SIMILARITY, between the black-white characters.
UNLIKENESS, between the (spacial) characters of extension, i.e. in shape.

In addition, further eductions of a more elaborate kind,

* For example, it hardly seems credible that the person who wrote the following letter to me ever brought the ideas expressed in the second paragraph into meaningful relation with each other. (It must be explained that I had had to make two trunk telephone calls to the firm concerned, regarding some goods which I had not received; and that I had written to them in protest.)

DEAR SIR, We are in receipt of your favour of the 11th inst., and regret that we omitted to send your order.

We herewith enclose our pro forma invoice for same, and are willing to send this carriage paid to meet the telephone calls.

(Cf. the quotation from J. W. N. Sullivan on page 272.)

involving the second and third processes as well, could take place; for example,

SIMILARITY, in that both are "regular" geometrical figures.
UNLIKENESS, in contour.

Which of these relations shall, on any particular occasion, be educed, and which shall not, depends, of course, on the quantitative determinants. Previous facilitation of one relation may cause that to be educed first; fatigue may in theory inhibit them all, though it is difficult to suppose that in practice anyone, however fatigued, could look at the items of Fig. 14 and fail to see them as somehow related; perseveration of one may inhibit the others; and volitional control may play an immensely important part in bringing about the eduction of one relation rather than that of another;* and so on.

3. IMPLICIT AND EXPLICIT RELATION EDUCTION

Whenever we walk between two familiar doorposts, instead of into one of them, we are behaving as though we had educed the relation of side-by-sideness which they bear to one another. But this relation would probably not be in consciousness at the time. Such behaviour is, of course, habitual. We educed the relation of side-by-sideness when passing between them on the first occasion or two; and now, through facilitation, we are able to react to the posts-as-related-to-each-other, without having to re-educe, or even consciously reproduce, the relation every time.

In such cases as this, in which we behave towards items grasped *in relation* to each other, the eduction is spoken of as being merely *im*plicit. In other cases, when we grasp that two items *are related* to each other in a particular way,

* Cf. p. 162.

and act accordingly, the eduction is said to be *ex*plicit. An example would be that of cautiously approaching and feeling for an unfamiliar doorway in the dark. We should explicitly educe that the posts were spacially related in such-and-such a way, before attempting to pass between them.

4. THE IMPORTANCE OF SPACIAL RELATIONS

To examine exhaustively the different kinds of relation which may hold between two items in cognition would be too lengthy and abstruse a proceeding for these pages; but the subject, which cannot be ignored entirely, is given a brief treatment in Appendix 2. Here it must be sufficient to examine a few of the many possible instances in which the importance of relations in cognition is obvious. The easiest to deal with in a printed book are, of course, spacial relations; and some examples of these are accordingly given.

(A) Visual symbols. As far as the first law of cognition alone is concerned the eight separate diagrams of Fig. 15 are identical. Each consists merely of two items, a straight line and a circle. But the spacial relation between the two items is varied, with the result that each diagram differs in meaning from the others. The first four become, when the constituent items are grasped in the appropriate relation, four letters of the alphabet; (v) and (vi) remain either meaningless patterns, or become the Greek letters *sigma* and *phi*, respectively; (vii) becomes, not a letter, but either two separate letters, or, if these are grasped in relation, the archaic word, *Lo*! (viii) is left to the reader.

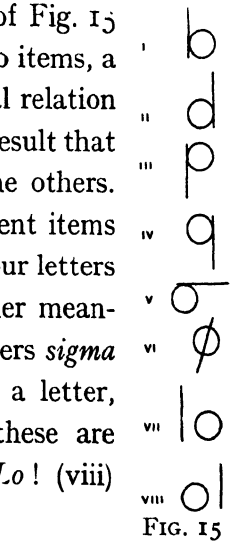


FIG. 15

(B) Words and their meanings. Other examples where the meaning depends as much on the spacial relations be-

tween the items cognized as on the items themselves are easy to find. A particularly obvious instance is that of the words

UNITE and UNTIE

These are practically antonymous, despite the fact that the items apprehended in the two cases by the first law alone are identical. The only difference between them lies in the spacial relationship of the two letters *I* and *T*.

The words

CAUSAL and CASUAL.

form almost as striking an example.

Similar examples are provided *ad lib* by printed and written numbers, where the meaning to be attached to the total symbol depends very largely on the particular spacial relationships which a very few component symbols bear to each other. In the Arabic notation there are ten basic symbols, and in the Roman system only seven, which can be permuted. But they are sufficient to bear an infinitude of meanings. Such a pair of numbers as

MCMXLIV and MMCLXVI

or

4,197 and 7,914

illustrate the importance of spacial relations to meaning in this connection.

Before leaving this topic it is worth remembering that in an earlier passage of this book (pages 59 and 60) several printer's " errors " were purposely inserted. It was explained at the time why it was possible to read such a passage without noticing the mistakes. From what has just been said it should be easy to see how one can grasp the meaning of a passage correctly despite errors in it. From the point of view of the meaning of a word read with ordinary speed, the relations between the symbols composing it are often as important as the symbols themselves. Thus it is that

remaiuder may function as *remainder*. A letter here, in a characteristic relation to the hint of the next letter but one, may well serve to convey the meaning of the entire word; unless the latter be so unusual as to demand the careful examination of every letter.*

(Not dissimilarly such an ambiguous word as "present" takes on different meanings and different pronunciations according to its grammatical relationship to the rest of the sentence in which it occurs. Thus: When next he is *present* we shall *present* him with the *present* we spoke of.)

(C) Pictures. Fig. 16, which, by the way, is printed upside-down, seems to most people at first to be merely a chaos of black marks on a white ground; but after some exploration it will be found possible to grasp the visual items as bearing explicit spacial relations to each other. When this occurs the chaos becomes a pattern, and takes on a meaning which it certainly did not have for the percipient before.† But here, again, it must be stressed that the actual *items* which are cognized remain the same, and not even their characters of quality (black-whiteness), intensity, spaciality or temporality, have changed. It is merely that the spacial relations, *which have existed all the while* between the items, have now been educed, whereas formerly they had passed unnoticed.

Further pictorial examples are worth considering. Most people grasp the black and white items of Fig. 17 in a definite and meaningful spacial relationship. They see some variety of goblet or pedestal. But it is possible, with precisely the same items, to educe quite other spacial relationships from between the different parts of the wavy

* Still further considerations which arise are discussed on p. 242 *et seq.*

† The person who "sees it as a face at once" is, of course, grasping the relations implicitly.

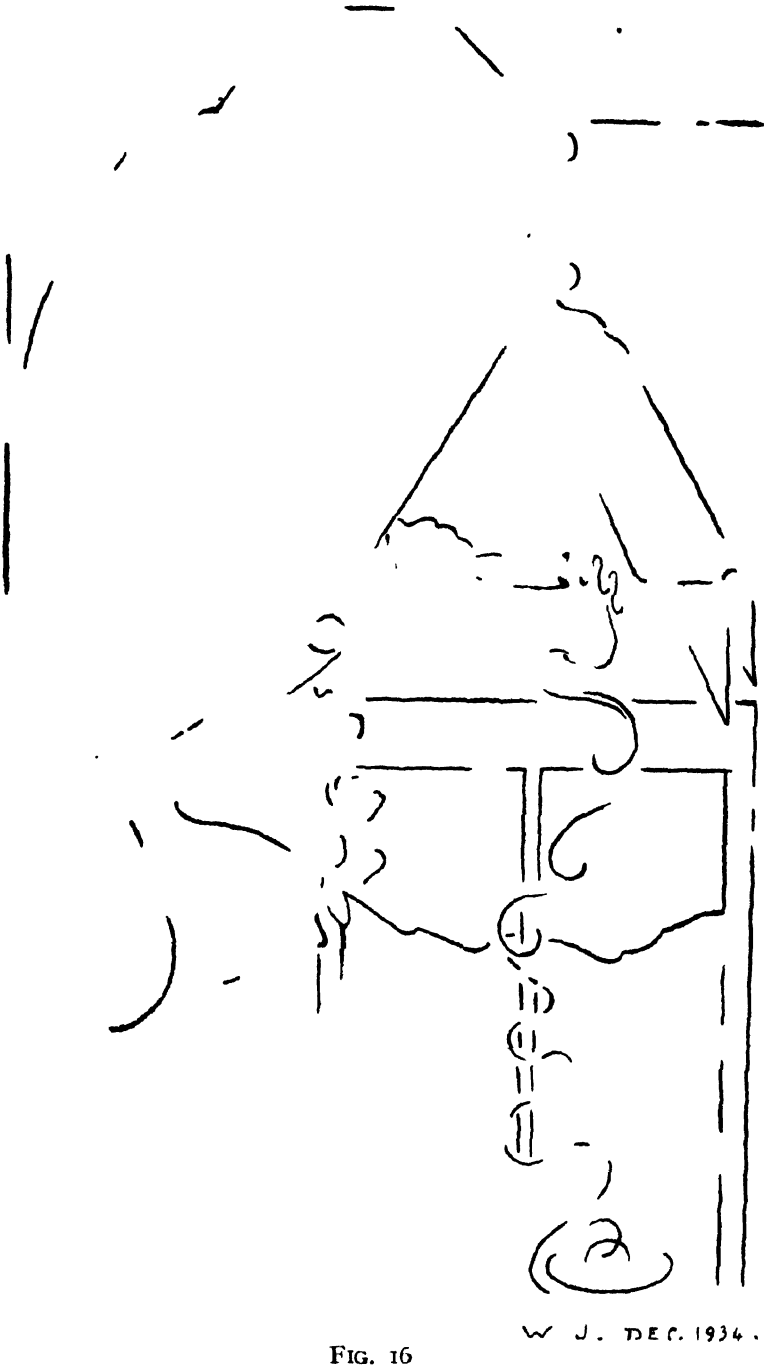


FIG. 16

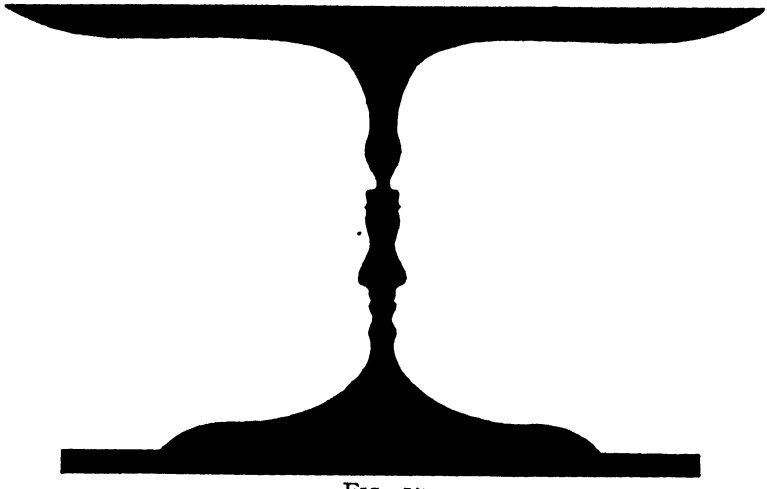


FIG. 17

stem. What was before a goblet or pedestal, then becomes something wholly different. Fig. 18, known as the " bird-

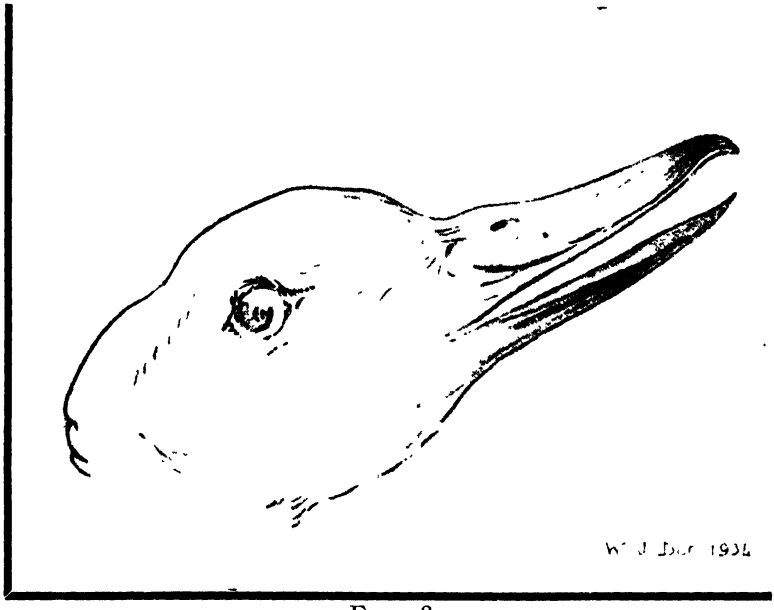


FIG. 18

rabbit " illusion, illustrates a similar point. The meaning attached to the visual items depends wholly on the relations educed between them. If the projections on the right are

grasped in the spacial relation implicit between the parts of a bird's beak, then the sketch becomes one of a bird. If, on the other hand, one happens to look first at the left-hand side of the sketch (this side being rabbit-like rather than bird-like) then the projections on the right will tend to function as ears; that is, the spacial relation implicitly educed between them will be that which is implicit between the ears of a rabbit.*

(D) The "Müller-Lyer" illusion. The well-known Müller-Lyer illusion shall provide our last example of the importance of spacial relations. In Fig. 19 (*a*) the horizontal lines corresponding to *x-y* and *y-z* are exactly equal in length; but to all except the most stupid people † the first appears to be markedly longer than the second. This is because it is almost impossible to cognize either horizontal line except as intimately related to the oblique lines which terminate it. Instead of judging the two horizontal lines alone, one inevitably judges the two spaces which the arrow-heads bound. The horizontal and oblique lines are so intimately related that it is practically impossible to deal with the former in isolation from the latter and from the spaces these delimit.

5. CONFLUENCE

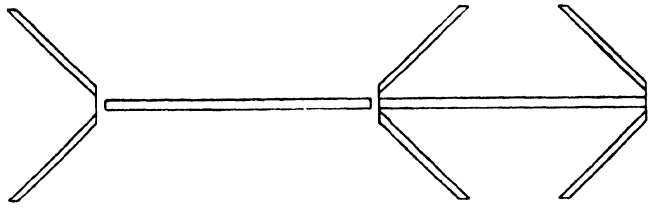
The Müller-Lyer illusion is commonly regarded as due to "confluence"; that is, to the "flowing together" of perceived items into a single unit. Confluence, in turn, is more often than not taken to be a basic and unanalysable mental process. More will have to be said about this later;‡ but we may in passing note that this process does seem to be wholly reducible to relation eduction. Items in awareness

* The "reversible perspective" diagram (Fig. 9, p. 93) is another example of different and incompatible spacial relations subsisting between the same visual items.

† Cf. p. 249.

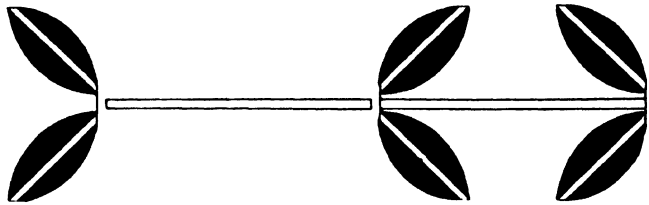
‡ P. 249 *et seq.*

(a)



x *y* *z*

(b)



x *y* *z*

(c)

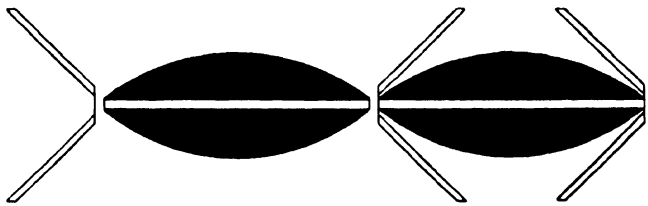


FIG. 19

tend to be confluent just in so far as they are grasped in relation to each other. By enhancing the arrow-heads of the Müller-Lyer diagram [Fig. 19 (*b*)], the illusion is exaggerated;* for the more obvious they are, the more obtrusively do they define the unequal spaces; and the more difficult it becomes to avoid educing the relations which bind the horizontal lines and the spaces together. On the other hand, by enhancing the horizontal lines [Fig. 19 (*c*)], confluence, and the illusion, is reduced. In this Figure the horizontal lines are so prominent that it becomes as easy to educe a relation between them as it is to educe one between the two entire lateral spaces. In Fig. 19 (*b*) it is the relations between the spaces, and in Fig. 19 (*c*) it is those between the horizontal lines themselves, which obtrude and tend to be educed.†

6. RELATIONS AND MELODY

Excellent illustrations of the importance of relations rather than of the things related can be taken *ad lib* from the realm of music. Fig. 20 gives the first four bars of the second subject in the first movement of Dvořák's *New World* Symphony. In (*a*) the phrase is in its familiar key of G major; while (*b*) gives the same phrase transposed a semi-

* Proofs of Figs. 19 (*a*) and 19 (*b*) were mounted on cards so that, in each diagram, the line *x-y* could slide underneath the line *y-z*. Subjects were then presented with the illusions closed (i.e., with only the arrow-head *x* protruding at *y* from beneath the line *y-z*) and were asked to withdraw *x* until they had exposed as much of *x-y* as seemed to them equal in length to *y-z*. Seven subjects each made 5 experiments with (*a*) and 5 with (*b*). The average errors were: for (*a*), 3.1 mms., and for (*b*), 4.3 mms. Thus, for this very small group of subjects, (*b*) gave, on the average, nearly 40 per cent. greater error than (*a*).

† In the present view Professor Victoria Hazlitt's thesis that "intelligence is a problem-solving organisation, and that its efficiency is the measure of the degree to which experiences are confluent" (*Ability*, p. 13) is tantamount to identifying "intelligence" with relation-eduction. Cf. also p. 249 *et sqq.*

tone lower into the key of $G_\flat$ major. If the two lines were played on any instrument, or sung, or whistled, or hummed, the least musical of people would probably recognize them

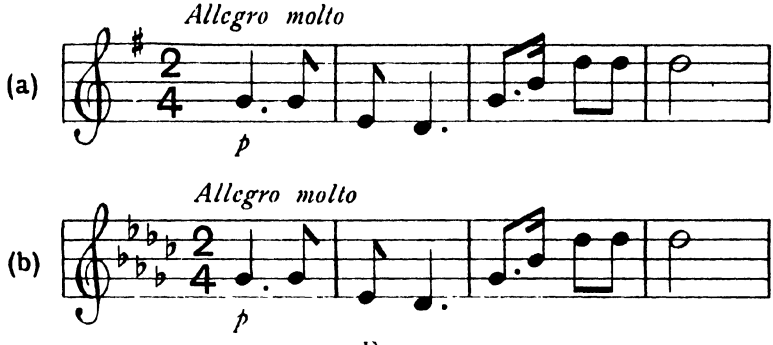
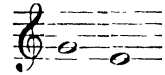
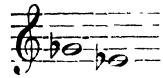



FIG. 20

as being the same melody. Yet not one of the *notes* in either (*a*) or (*b*) occurs in the other. All that remains the same is the *relationships* of the notes to each other; and it is that alone which gives the tune its individuality. The interval, or pitch-relation  , for example, is exactly the same as the interval  , although the related items are wholly different.

7. RELATIONS IN ANIMAL PSYCHOLOGY

(A) Mammals.*

(*I*) *RATS.* Lashley records experiments in which rats which had been trained to behave in a certain way when they saw a white pattern on a black ground, reacted equally well to the same pattern in black on a white ground, to mere

* Köhler's *Mentality of Apes* provides many examples of relation-eductions by these animals. So does the behaviour of a sheep-dog rounding up a flock, particularly on a difficult mountain side, or in a sheep-dog "trial". The dog sees the sheep in one direction; moves off in quite a different one; approaches them from the side, or from behind; lies down between them and tempting side-tracks; and so on.

outlines of the solid figures, and even to " partial outlines which preserved some of the proportions of the original figures " (1). In other words they react not only to particular visual items, but also to different items if these happen to have the same spacial inter-relationships.

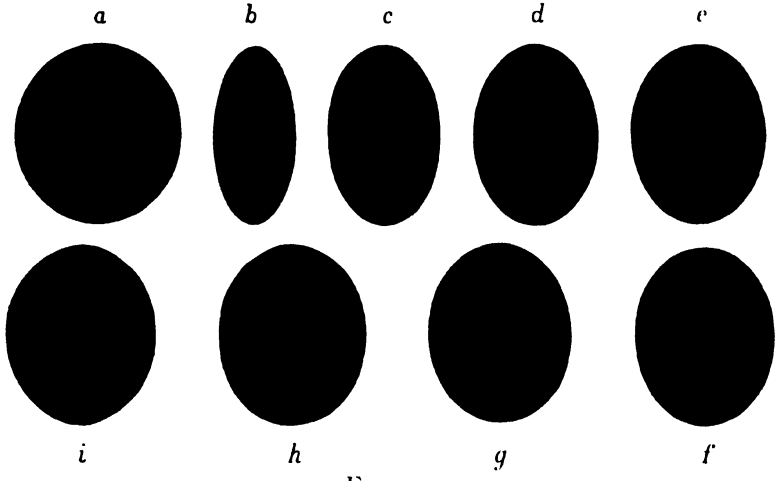


FIG. 21

(*II*) *DOGS.* By the method of conditioning described already (page 73) Pavlov trained a dog to associate a circle of light [(*a*) in Fig. 21] with food. He then taught the same dog to associate a narrow ellipse (*b*) with the absence of food. When this had been achieved, wider and wider ellipses [(*c*), (*d*), (*e*), etc.] were substituted for (*b*), until one (*h*), having its axes in the ratio 8 : 7 was reached, each having in turn been successfully discriminated from the circle (*a*). When, however, the attempt was made to get the dog to associate (*i*), where the axes are in the ratio 9 : 8, with the absence of food, he proved unable to make the discrimination between (*i*) and the circle, and had a nervous breakdown (2). In other words, the dog was able in some way to treat even (*a*) and (*h*) as different ; but the relation of difference between (*a*) and (*i*) proved too slight for him to be able to react to it.

(B) Birds.

(*I*) *HENS.* Köhler's well-known experiment with chickens indicates that even these lowly creatures also react on occasion to relations between things rather than to the things themselves. The chickens were trained to go always to the darker (II) of two grey surfaces [Fig. 22 (*a*)] for food.

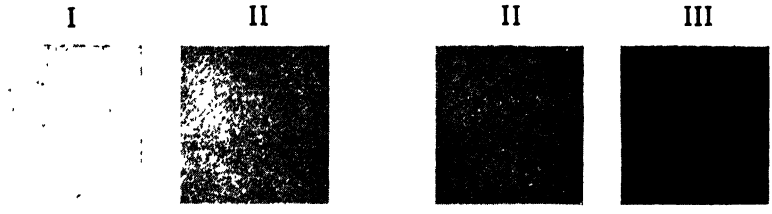


FIG. 22

When training was so complete that they went always to II whether it was to the left of I or to the right, surface III [Fig. 22 (*b*)] was substituted for I, III being slightly darker than II, just as II had been slightly darker than I. In these circumstances it was found that the chickens went consistently towards III, the darker of the new pair, and not to II, the actual surface where they had always found food before (3). It is evident, then, that they reacted not to II, the constant item in both situations, but to the constant relation of difference-in-brightness which held as much between III and II, as between II and I.

(*II*) *JAYS.* Hertz describes some experiments in which a " tame " jay sees some food put under one of a number of small flower pots. If the pots are arranged as in Fig. 23 (*a*), or (*b*), or (*c*), the food being hidden, in each situation, under the pot marked " X ", then, when the experimenter has gone away, the jay will fly down, overturn the right pot, and secure the food. But if the pot with the food under it is placed as in Fig. 24, whether the bird finds it or not is purely a matter of chance (4). As with Pavlov's unfortunate

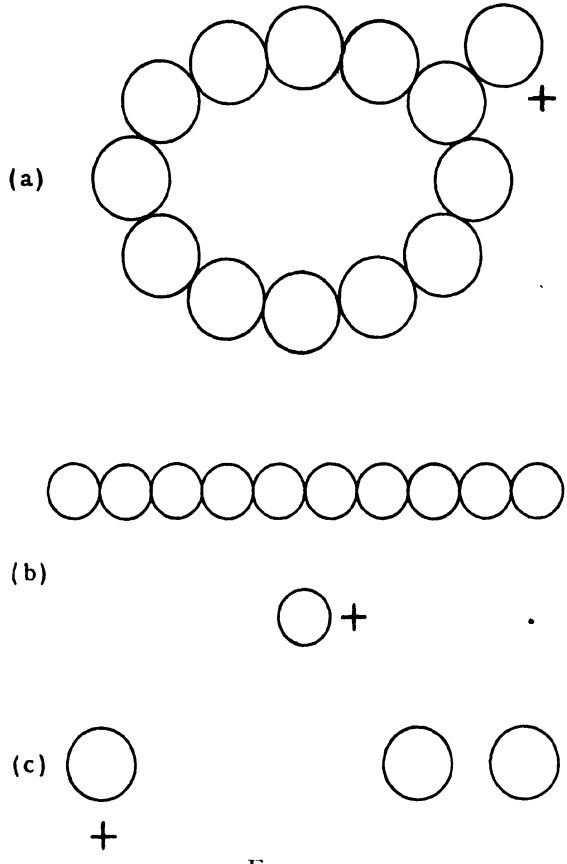


FIG. 23

dog, some relations of difference are too subtle to guide the creature's behaviour successfully.

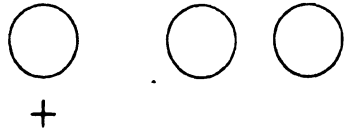


FIG. 24

(C) Insects. That even insects are capable of relation eduction may be a rather startling conclusion; but it certainly seems to be justified by McDougall's account of an experiment made with a female solitary mud-wasp (5). The creature was constructing a cluster of cells by attaching

pellets of clay to a hanging wire. When one particular cell was almost complete, " the wire . . . was cut and inverted, so that the unfinished cell was at an angle of forty degrees from the vertical ". The unfinished cell thus had its open end pointing downwards instead of upwards, the latter being the only method of construction used by wasps of this kind. McDougall says that " the wasp, returning with a pellet, seemed disconcerted ; after some fussing about, she laid the pellet on the upper closed end of the cell " (where, of course, it was quite unnecessary, and contributed nothing to the completion of the cell). " But, on returning with another pellet, she laid this *after some hesitation* * on the unfinished margin of the cell, and so continued until the wall was completed." It is clear that this insect certainly succeeded in reacting correctly, despite the wholly novel and disturbing spacial relations which McDougall had arranged.

8. CONCLUSION

The upshot of this chapter is, then, that not only do we become aware of things, but that we can and do become aware of relations between things. Further, these relations are of the utmost importance. Examples have been given where the cognized items have no meaning whatever until relations have been educed between their constituents ; other examples where the same items take on different meanings according merely to the particular relationship they happen to have assumed on the given occasion ; and still another example where cognition is at fault simply because the obsessive effect of non-essential relations between items prevents our cognizing the items as such. And, lastly, we have seen that spacial relations between the

* McDougall's italics.

things they see modify very definitely the behaviour of certain animals. That is not to say that these animals become explicitly aware of the relations, any more than the unsophisticated victim is explicitly aware of the misleading relations of the Müller-Lyer illusion. The points made are merely

(1) that relations do implicitly come to consciousness in such a way as to modify the behaviour not only of human beings, but of other animals as well; and

(2) that human beings can, and on occasion do, become explicitly aware of the relations.

When the relations only come to mind *im*plicitly, we speak of perceiving *the items in relation*. When the relations are *ex*plicit, we perceive *that the items are related*. (Cf. page 148.)

It is to be added that in either case, if the awareness of relation occurs, it does so *immediately*, just as the apprehension of an experience follows *immediately* on sentience. There are no mediating steps in the relation-educing process; it is one of the fundamental and unanalysable "givens" of the psychology of cognition. Lastly, it must be remembered that this law describes only a tendency. As we have said, one seldom educes *all* the possible relations from between even quite simple items; the quantitative determinants, particularly that of the constancy of cognitive output, prevent this. It is quite possible, for example, to look at Fig. 17 repeatedly, and never to see the faces of which the stem is composed. If this has occurred to the reader he is advised to cover up one or other vertical half of the "pedestal", and so to do away with the relations which were first educed, and which by now have been too much facilitated to permit the eduction of the others.

9. ADDENDUM: ON ASSOCIATION

(A) The mechanism of association. The bare fact of association, that mental events which occur together tend to do so subsequently with greater ease, has been discussed sufficiently already [chap. 9 (B)]. But a few words may be added concerning the underlying psychological mechanism of this important phenomenon.

Associations between ideas have been regarded as divisible into four types, namely :

(1) association of *similar* ideas,
(2) association of *contrasted* ideas,
(3) association of ideas presented *simultaneously* to awareness, and
(4) association of ideas presented *contiguously* to awareness.

But this view has been modified in different ways at different times. In the first place it has undergone various simplifications, even to the extent of regarding association by simultaneity as being the only type. The ideas of *white* and *snow*, for example, have been held to be associated, not because they possess similarity, but because we have experienced them simultaneously ; and the same has been held of the contrasted ideas of *white* and *black*. This is probably the soundest view to be obtained along these lines ; for if an idea is immediately succeeded in consciousness by a similar or contrasted one with which it has never before been in mental juxtaposition, it is clearly inaccurate to speak of them as having been already associated. We should say no more than that the first *suggested* the second.* Further, ideas which are experienced together in space, must also be experienced together in time ; and so association by con-

* By the process of *correlate eduction* described in the next chapter.

tiguity in space has also been subsumed under association by simultaneity, or contiguity in time.

In the second place, the concept of association has also been made more complex; it being realized that not only ideas, but also other mental events, for example, orectic ones, may enter into associations. This has already been discussed sufficiently (page 72 *et sqq.*).

But introspection shows that all such classifications as we have discussed are rather arbitrary. They may be logical; but they are hardly psychological. The fact open to direct verification by everyone is that association may take place by means of any relation whatsoever; and we may say that any mentally apprehended items (simple or complex, cognitive or orectic) which have been experienced in relation to each other, mutually tend to reinstate each other if, for any reason, one of them again enters awareness (6). Thus it is that, as in the example on page 128, cognition of (*a*) a photograph is associated with (*b*) recollections of the person it depicts, instead of with (*c*) some recent event. (*a*) and (*b*) have been grasped in relation to each other; (*a*) and (*c*) have not.

(B) Illustrative. This point is illuminated by a well-known parlour game. You first memorize a list of a dozen or twenty "key" words, pairing each with the number of its position in the list. My own list, compiled for demonstration purposes in lectures on association, begins,

One	—	Orange
Two	—	Tooth
Three	—	Tree
Four	—	*Fore*!
Five	—	Fife
Six	—	Sticks

and ends,

Twenty	—	love-sick maidens.

(Before continuing we may as well note two points. (1) Even the sequence of numbers *one* to *twenty* is not mastered purely by rote. In learning it the child has to grasp a relation of immediate succession between, say, *four* and *five*; otherwise, when asked what comes after *four*, he is just as likely to say *seven* or *two* as to give the right answer. (2) The list of " key " words is easy to remember just in so far as the relations between its members and the corresponding numerals are vivid. It does not matter that the relations are arbitrary, artificial, illogical or merely assonant or punning. *Two-tooth* may be puerile, for example; but it is quite unforgettable.)

You then invite people to suggest any words they like, and you undertake to remember them all. Two precautions have to be taken. First, as each word is spoken it has to be numbered, partly for identification purposes afterwards. Secondly, the idea underlying each word has to be brought into vivid relationship with the idea behind the corresponding " key " word.

Thus, if the first word is *elephant*, you have merely to think of an elephant and an *orange* in some clear relationship. He may be playing football with it, jumping on it, juggling with it, or just sitting down and eating it. Any relation will do. The second word, shall we say, is *adventitious*; you picture someone with *teeth* growing all over him. Next comes *Agamemnon*; and you think of the mighty war-lord reposing beneath a *tree*. When the twenty test words have been brought into vivid relationships with the twenty " key " words, it is perfectly easy to reproduce them on demand, in any order. Someone asks for word number two. Your associations are simple:

two —→ *tooth* —→ *teeth* —→ *man with adventitious teeth* —→ *adventitious.*

The chances are that no one else will remember the word at all; for, although they also experienced *two* and *adventitious* together, those ideas were not brought—even indirectly—into mutual relationship; and, therefore, it is extremely improbable that they are in the least associated for anyone except yourself. The only difficulty likely to be experienced is with synonyms; you might, for example, tend to give *accessory* instead of *adventitious*. But, once a list has been memorized in this way, it may even become difficult to forget it.

(C) Conclusion. It is, then, necessary to postulate the law of association as only a tendency. Events which have occurred together tend to become associated in so far as they have been grasped in relation to each other; but, as we saw on page 147 *et seq.*, relation eduction is not inevitable. It is when relations are, at least implicitly, educed between items experienced simultaneously, that the tendency of the latter to become associated matures.

REFERENCES

(1) K. S. Lashley, *Basic Neural Mechanisms in Intelligence*, PR, 1930.

(2) I. P. Pavlov, *Conditioned Reflexes*, p. 290 *et seq.*

(3) Dr. Mathilde Hertz, *Zeitschrift für Vergleichende Physiologie*, vol. 7, 1928.

(4) Quoted by Köhler, *op. cit.*, p. 121 *et seq.*

(5) W. McDougall, *Energies of Men*, p. 36 *et seq.*

(6) Cf. Aveling, *Directing Mental Energy*, chap. 6.

CHAPTER TWENTY-ONE

THE EDUCTION OF CORRELATES

1. The Third Psychological Law.
2. An Illustration from Music.
3. Diagrammatic Representation of the Three Cognitive Processes.
4. Further Illustrations of Correlate Eduction.
   (*A*) In solving a crossword puzzle.
   (*B*) In language acquisition.
   (*C*) From child psychology.
   (*D*) Mathematical.
5. Transcendental Correlates.
6. Illustrations of Correlate Eduction (Continued).
   (*A*) Hume's paradox.
   (*B*) The notions of physical *force* and *causation*.
   (*C*) The first cause.
   (*D*) Unconsciousness.
7. Summary.
8. Terminology.
   (*A*) Noesis.
   (*B*) Genesis.
   (*C*) Noegenesis.
   (*D*) Anoegenesis.

1. THE THIRD PSYCHOLOGICAL LAW

Now we may turn to the third cognitive law, which describes the only remaining process by which we can pass from ignorance to knowledge. This is the Law of the Eduction of Correlates, namely, that *awareness of an item together with that of a relation tends to be followed immediately by awareness of the correlative item.* By now all these terms have been introduced, except that of "correlative item", or, more simply, "correlate"; so it will be sufficient to take a few examples, chosen merely to illustrate this term vividly.

2. AN ILLUSTRATION FROM MUSIC

The following example illustrates all three processes in operation. Let two musical notes, say, *C* and *G*, be struck successively on the piano. Then, by virtue of the first process of experience-apprehension, there will be a tendency for two auditory cognitions to take place ; and, by the second process of relation-eduction, a relation of difference, called by musicians a *perfect fifth*, will tend to be educed between them. Let us suppose that both these tendencies mature, and that apprehension and eduction both take place. Now let any other note, say, *E*, be struck. A musical person will be able to apply the educed relation *perfect fifth* to this new note, and so educe a fourth note, *B'*, which bears this same relation to it. That fourth note is spoken of as the *correlate* which has been educed ; and the said musical person would be able to whistle or sing or hum it, or pick it out at once on the piano.*

3. DIAGRAMMATIC REPRESENTATION OF THE THREE COGNITIVE PROCESSES

This seems the place to introduce a diagrammatic representation of the last three processes discussed, of which use will frequently be made in the following pages. In Figs. 25 to 28,

(*a*) Shaded rectangles represent initial *lived experiences*.

(*b*) Open rectangles represent *apprehensions*, the products of the *first* process.

(*c*) Circles represent *relations*, the products of the *second* process.

* Cf. Lashley, who speaks of " A student of piano who, in the stress of a public recital, unknowingly transposed one-half tone upward an entire movement of a Beethoven sonata, a feat which she had never attempted before and could not duplicate afterward even with some practice." *Brain Mechanisms and Intelligence*, p. 159.

(*d*) Hexagons	represent *correlates*, the products of the *third* process.
(*e*) Firm lines	represent the initially given items from which a particular process takes its start.
(*f*) Broken lines	represent the processes themselves, and the resulting apprehensions, relations, or correlates.
(*g*) Σ (or ⋈) *	indicates that the items thus joined are linked together in awareness.

Thus, in the musical example of paragraph 2 (*supra*), we have first of all the apprehension of the two experiences, *C* and *G*. (Fig. 25.)

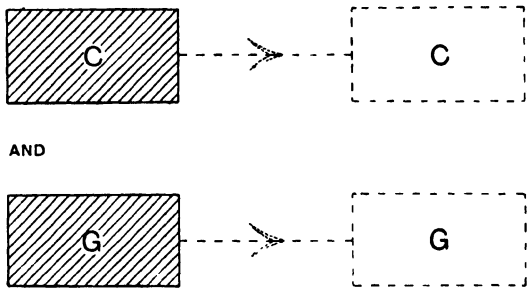


FIG. 25

Secondly, there results from these successive apprehensions, the eduction of the pitch-relation which holds between them. (Fig. 26.)

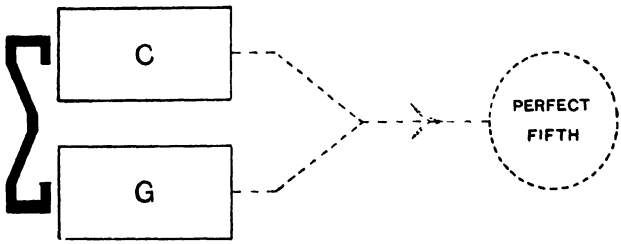


FIG. 26

* The Greek (capital) letter *sigma*, conventionally used by mathematicians to denote the ideas of *summation* and *integration*.

Thirdly, the new experience, E, is apprehended. (Fig. 27.)

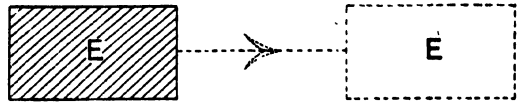


FIG. 27

Lastly, the educed relation is applied to the cognized E, and the correlate B' is educed. (Fig. 28.)

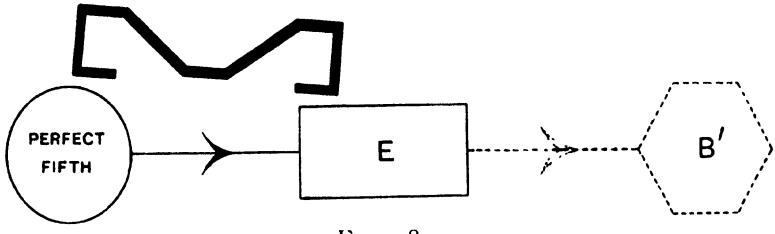


FIG. 28

In Fig. 29, where the firm and dotted line convention is abandoned, the entire sequence of processes is depicted.

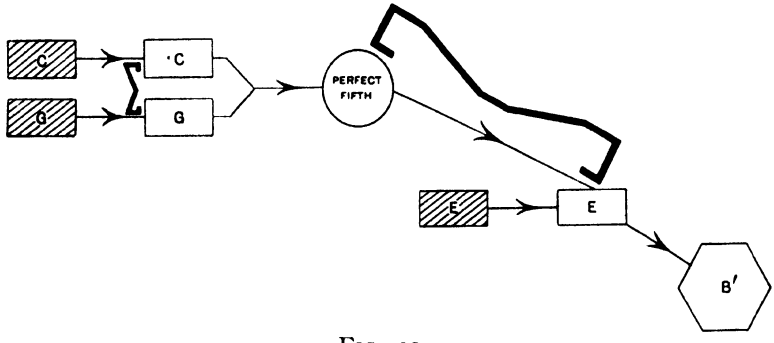


FIG. 29

4. FURTHER ILLUSTRATIONS OF CORRELATE EDUCTION

(A) In solving a crossword puzzle. Another example of correlate eduction can be taken from the experience of the crossword puzzler whose clue is "opposite to slow". In this case he is given not a percept but an idea (slow) and a relation (opposite to). What he requires is the correlate

which can be educed by applying the relation to the idea. That correlate will, in a sense, be the solution of his problem. But an educated person would be able to *repro*duce associatively many synonymous verbal expressions which would fit the notion " opposite-to-slow " equally well. Fortunately the crosswordist can apply other relational systems which will limit his choice among the several alternative words which he may have reproduced. He may know, perhaps, that the fourth and fifth letters are *e* and *d* respectively. Then the solution must be either *speedy* or *expeditious*. Which of these two it is will be settled by purely spacial relations. He will already know whether the word requires six or eleven letters.

The reader can follow for himself the processes of eduction and reproduction required to obtain the correct verbal form of the correlate in the following example :

ITEM :	Tree.
RELATION :	Part of.
CORRELATE MUST HAVE :	*a* for the *third* letter ; and, *six* letters, not *four*.

(B) In language acquisition. The successful application of grammatical rules in novel contexts plays an important part in mastering a foreign language, and forms a good example of correlate eduction. A boy learns the rule that in French the first person singular of the future tense of a regular verb whose infinitive ends in *er* or *ir* is formed by adding *ai* to that infinitive. The rule is illustrated for him by many common examples ; and once he has grasped the relation between

donner and *donnerai*,
finir and *finirai*,

and a few more pairs of infinitives and futures, he is potential master of this tense of a whole host of verbs. It does

not matter that when he learnt the rule he had never heard of many of them, or even that he will never hear of others at all. He can now apply the relation not only to *passer*, which he knows already, thus obtaining *passerai*; but even, should he meet it later on, to the somewhat esoteric *ergoter*, correctly educing *ergoterai*.

A further example, this time of faulty correlate eduction in language acquisition, is worth giving. The present writer had, when at school, to translate into French the phrase, "the cow was eating the grass". The rendering he gave was, "*la vache frangeait l'herbe*". The master's surprised correction, "*Mangeait*, surely? There's no such word as *frangeait*", was greeted with "No, sir! *Mangeait* for people, *frangeait* for animals." The origin of the mistake was as follows. I had then only recently begun the study of German, and had just learnt that *essen* and *fressen* were verbs referring respectively to eating by humans and by animals. The relation which the notion of *fressen* (animals-eating) bears to *essen* (humans-eating) had been educed, isolated from its German context, and applied to the notion *manger*; the erroneous correlate *franger* being educed in turn. Thus it was that my *vache* had to *franger*; it was only humans who could *manger*.

(C) From Child Psychology

i. When about eighteen months old, a niece of the present writer was in the habit of making a sound that can best be written as "Nemmi", whenever she wished to refer to bread-and-butter. She saw, for the first time, during an outing, a horse eating hay in a field, and promptly gave vent to an excited cry of, "Gee-gee's nemmi! Gee-gee's nemmi!"

ii. In his autobiographical *Father and Son*, Edmund Gosse writes, "I had often watched my Father, while he soaked the flesh off the bones of fishes and small mammals."

"A lady—when I was just four—rather injudiciously showed me a large print of a human skeleton, saying 'There! you don't know what that is, do you?' Upon which, immediately and very archly, I replied, 'Isn't it a man with the meat off?'" (1).

iii. An acquaintance of the present writer, aged four years and as many weeks, had become very interested in maps and atlases. The map of Europe was pointed out to him, and he evidently understood the word as *your-ope*, for he thereupon proceeded to refer to it himself as "*My*rope", and refused for quite a while to be persuaded that the relation of *your* to *my* was inapplicable in this particular context.

(D) Mathematical. When a boy learns, for example, that the relation between the Centigrade and Fahrenheit conventions of measuring temperature can be expressed by means of a simple "conversion graph", he is at once potentially capable of dealing with any other pair of comparable conventions in a similar way. He can now apply the relation of equivalence which his first graph expresses to the idea of yards, and draw a graph which will convert them into metres; or to dollars, converting these into shillings, francs, marks, yen, roubles, or any other currency.

Several further examples of correlate eduction appear in the processes by which such complex mathematical notions as 0, -1 and $\sqrt{-}$ may be built up. From such pairs of numbers as 9 and 8, 3 and 2, 76 and 75, the relation *one-less-than* can be educed. This can be applied to the idea of *one*, and the correlate, *one-less-than-one* can be educed and symbolized by the cypher 0. But the same relation can further be applied to this new correlate, and another correlate, *one-less-than*-0, of a still higher order, can be educed and represented symbolically thus: -1. Again, between such pairs of numbers as 2 and 4, 10 and 100, 7 and 49, $\frac{1}{5}$ and $\frac{1}{25}$, 1 and 1,

the mathematician can educe the complex relation which he represents by the symbol $\sqrt{\ }$, and calls *the square root of*; and there is nothing to prevent him from applying this relation to the previous correlate -1, thus educing the extraordinary notion $\sqrt{-1}$. The entire process is shown diagrammatically in Fig. 30; though it is not suggested that this is the only, or even perhaps, the normal method of arriving at this complex idea of a number which, when multiplied by itself, becomes -1.

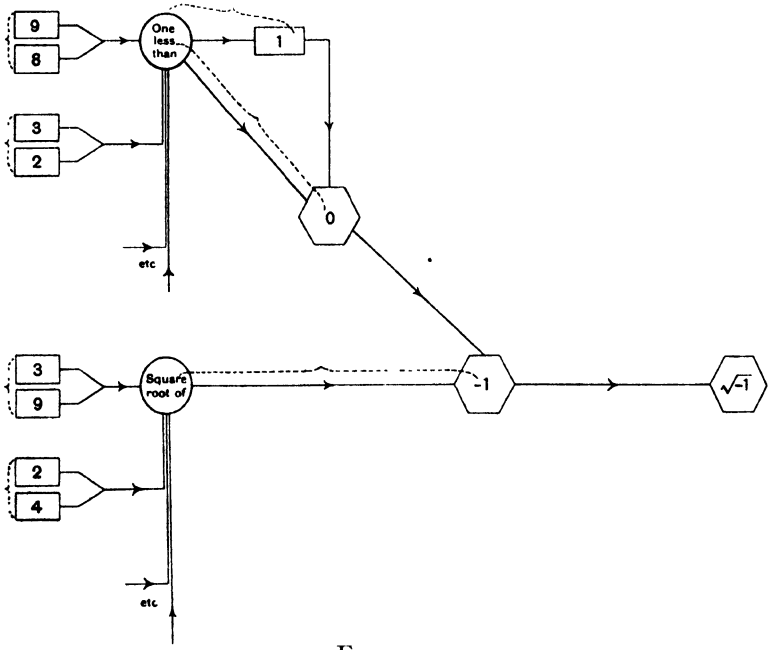


FIG. 30

5. TRANSCENDENTAL CORRELATES

The mathematical examples of the last paragraph raise two very important points. In the first place the idea $\sqrt{-1}$ passes entirely beyond, or *transcends*, experience. It corresponds to nothing whatever within anybody's actual or possible experience; and could not have been arrived at either by mere apprehension or by educing the relations

which are to be found between apprehended items. It is a supra-experiential cognitive construct; for no number, when multiplied by itself, can ever give any negative result whatever. In the second place, these mathematical examples illustrate the important fact that the items from which correlates can be educed are not limited to apprehended items, the products of the first psychological process; they may themselves be correlates such as 0 and −1, the products of the third process. As a matter of fact correlates can also be educed by applying relations to relations. The notion $\sqrt[n]{\ }$ can be arrived at by applying the relational system represented by the phrase *indefinite repetition* to the relations $\sqrt{\ }$, $\sqrt[3]{\ }$, $\sqrt[10]{\ }$, and so on.

6. ILLUSTRATIONS OF CORRELATE EDUCTION (*Continued*)

(A) Hume's paradox. A very striking example of correlate eduction is the following, taken from Hume's *Treatise of Human Nature* (2). "Suppose a person to have enjoyed his sight for thirty years", Hume wrote, "and to have become perfectly well acquainted with colours of all kinds, excepting one particular shade of blue. . . . Let all the different shades of colour, except that single one, be placed before him, descending gradually from the deepest to the lightest. . . . Now I ask, whether it is possible for him, from his own imagination, to supply this deficiency?" Hume's own doctrine was that all knowledge consisted solely of present perceptions and fainter reproductions of former ones. Consequently he was bound to hold that a person in the position he described would be unable to "imagine" the missing tint. It had, *ex hypothesi*, never been experienced; and there was nothing therefore which he could reproduce, however faintly, from his past cognitions to fill the present

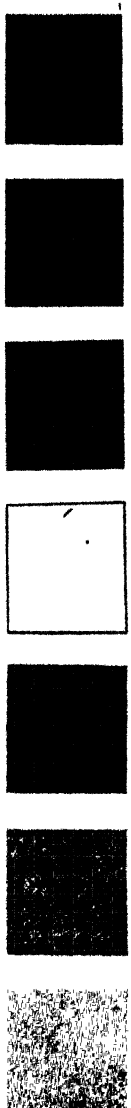


FIG. 31

gap. Hume's own comment was, "I believe that there are few but will be of opinion that he can [imagine it]", with which we can certainly agree; but we must disagree emphatically when he continues, "The instance is so particular and singular, that 'tis scarce worth our observing."

There seems no doubt that anyone could, "in imagination", fill a gap in experience such as Hume postulated. The process by which this would be achieved would be that of correlate eduction. Let some of the adjacent tints be represented by the squares in Fig. 31, *m* denoting the missing shade. Passing from left to right the subject would be able to educe the relation *darker than* from between any of the pairs of tints; and arriving at *l*, he could educe the correlate, *darker than l*. But this correlate is too vague, for it includes not merely *m*, but also *n* and *o* and all the remaining darker tints. He would therefore have to work from right to left as well, and "imagine" a shade which was not only *darker than l*, but also *lighter than n*. By such a double process could a tint, never before experienced, be *educed* as a correlate from the given data; and it would perfectly fit Hume's hypothetical gap.

(B) The notions of physical *force* and *causation*. Another very important

example of correlate eduction is that by which we come to regard inanimate objects as exercising force, or as behaving causally. In particular, things in the external world move and meet; and after they have met we see that each has been in some way modified. The elastic loses its tautness and its shape, and the stone flies from the catapult. It strikes a leaf and a twig; the first is dislodged, and the second broken. The stone itself falls to the ground, where it rolls erratically to a standstill. Now it is quite certain that, when we see a stone roll along the ground, all that is actually perceived is a bare sequence of events. Certainly it *appears* as if it were the resistance of other stones which *causes* it to change its direction at each contact; just as it also *seemed* as if the stone itself had *forced* the twig to break and the leaf to fall. But this is due merely to an acquired mode of thought which has become habitual, and does not correspond with any insight into the real nature of physical events and their sequences.

The notions of force and cause are no more than relations which we have educed from our own complex conative and volitional experiences. I have forgotten something, I strive to remember it, and succeed in doing so. In that situation I experience *myself* as causal and forceful; and between the two mental events, my striving on the one hand and my recollection on the other, the relation of cause to effect is self-evident. So it is on another occasion when I am performing some difficult and unpleasant cognitive task, but, by *forcing myself* to do it, I finally accomplish it. And again; I decide to post a letter, put it in my pocket, and later, when passing a pillar box, I carry out my decision. Here the act of will is the cause, and the posting the effect; and the causal relation can be educed from between them.

By a process of correlate eduction the forceful and causal relations, once extracted from the conative and volitional experiences which are their natural context and only fount, can be applied to observed sequences of events in the physical world; so that it becomes "second nature" to regard either the hammer or the blow as the *cause* by which the nail is *forced* into the leather. But it remains a fact that all we *observe* is a *temporal* sequence of events. The further fact that we unconsciously superimpose a causal sequence upon the temporal one is due, not to observation, but to an automatic supplementation of observation by way of correlate eduction.

It is worth while, in this connection, to remember what has already been said (page 2) about gravitation. Newton accepted the Euclidian ideas of a space in which it is no more incumbent upon a free body to move in one direction rather than in another, and so had to postulate a gravitational *force* to account for the observed tendency of such bodies to move earthwards. Einstein's contribution has been to do the obvious thing and to develop a new concept of space, in which it is inevitable that free terrestrial bodies should move as they do. He is therefore able to dispense entirely with the notion of force in his treatment of the same phenomena.

(C) The first cause. Another very important example of correlate eduction is that by which we arrive at one of the more sophisticated notions of God; namely, that of God as the *primary cause* of the Universe. Clearly, not even the most devout and uncompromising theist can have any immediate *personal* awareness of his Deity in this connection; but the relation of cause, once educed from his own conative and volitional experiences, can be transferred from this context to the Universe thought of as a whole. Thus he

can think of a Being which bears to the Universe the same causal relation which he himself bears to the mental products of his own successful conations and accomplished volitions. Obviously such a concept *need* have no more actual existence than has a *flying pig*, or $\sqrt{-1}$; the causal relation, for all we can know, may have no valid reference whatever outside its own special realm, which is that of our own personal *self*-experience.

(D) Unconsciousness. The last example of correlate eduction which space permits for the present is the very important one of perceiving something as inanimate and unconscious. It is self-evident that *un*consciousness can never have been a part of anyone's conscious experience, and the notion cannot therefore have arisen by means of the first psychological process. Again, unconsciousness is hardly a relation which we could educe by the second process from between any experienced items. But, " If something, say, a gesture or a certain type of movement has once been taken as having some significant relation to consciousness, then that same relation, applied to the negation or absence of that gesture or movement will tend to be followed by the eduction of the correlative idea of unconsciousness " (3). Suppose, for example, that while you are watching a Rugby football match from the touch line, a player near you makes a late tackle, misses, and is kicked on the head. You go to pick him up, and, as you do so, he speaks, or moves as though to pick himself up. You conclude that he is still conscious. If on another similar occasion he were to make none of these responses, you would tend to educe the notion *not-conscious*; even though this idea had never formerly occurred to you. The same idea can be reinforced—though not, perhaps, arrived at—by an even simpler process of correlate eduction. The relation of *oppositeness* can be

educed from many different pairs of experiences; and, however educed, it can be applied to the notion of consciousness.

7. SUMMARY

Items of six varieties (sensory, hedonic, conative and volitonal experiences, cognitive acts, and the ego itself) can be apprehended by the first psychological process alone; and relations of ten kinds (see Appendix 2) can be educed from them and their characters. But, when we have done all this, we remain still anchored to experience and to the relations which already held between its items and their characters. It is by the third process of correlate eduction that relations once educed *from* experience can be turned back *upon* experience; and, when this happens, there is the possibility of our *transcending* experience and passing in thought into the infinite realms beyond. Thus it is that we can *think* of such intangibilities as the first cause, unconsciousness, $\sqrt{-1}$, physical energy and causation, indivisible atoms, evolution, the velocity of light, beams of ultra-short radio waves, and the rest of the mental equipment of the modern educated man.

8. TERMINOLOGY

Before passing on to survey more systematically the vast field in which these three fundamental laws of cognition apply, two further points about them are worth consideration.

(A) Noësis. In the first place it is important to note that the cognition which is the outcome of apprehension and of the two eductive processes has always the character of being *noëtic* or self-evident. When an experience is apprehended there is always insight that it is *as apprehended.* The same holds for eduction. When, for example, the relation of verticality is educed as holding between the two black dots of

Fig. 32, there is an accompanying insight that the relation really subsists between them; the relation of verticality,

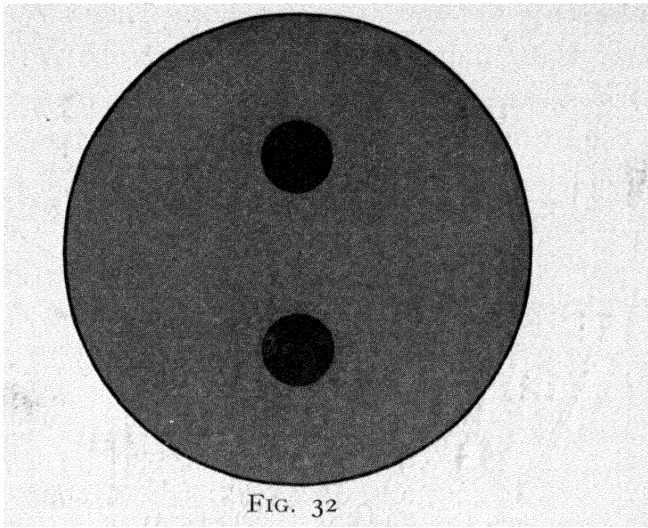


FIG. 32

once educed, is self-evident or noëtic. This is also true of correlates. A simple example, again referring to Fig. 32, is provided by the meaning of the phrase *within the circle*. As soon as the relation *within* has been successfully applied to the perceived circle, it is self-evident that the correlate, which can be in this case verbalized as " the shaded area ", *is* the meaning of the phrase. That is not to say that every correlate is true in the sense of conforming to some self-existent extra-mental reality. All that is implied is that even such a correlate as that of *flying pig* is, when educed, noëtic; that is, self-evidently a perfectly fitting correlate in this instance. It is not, on the other hand, self-evident that the Battle of Hastings was fought in 1066. The three processes of apprehension, relation eduction, and correlate eduction are therefore termed *noëtic*; their products are *self-evidently so*.

(B) Genesis. A second feature of these three processes is that, between them, they account for the entire birth and

growth of cognition. There are no other processes whatever by which we can pass from ignorance of ourselves and our environments to knowledge of either. They alone account for everything that is *new* in cognition.*

(C) Noëgenesis. Thus it is that the term *noëgenesis* has been coined by Spearman to describe these three processes, and to emphasize their chief characteristics. These processes alone account for the generation of new cognition; and such cognition, when generated, is noëtic or self-evident.

(D) Anoëgenesis. The two processes of clearness variation and reproduction may, in contrast to those of apprehension and eduction, be termed *anoëgenetic*; for their manifestations are neither noëtic nor generative of new cognitive content.

REFERENCES

(1) Edmund Gosse, *op. cit.*, chap. 2.
(2) Cf. Spearman, CM, pp. 24-25.
(3) NP, pp. 248-249.

* This statement will be disputed by those who hold that knowledge may arise in such ways as the following: Direct Divine Revelation. Mystical experience. Mediumistic intercourse. Telepathy. Clairvoyance. Precognition (Cf. J. W. Dunne, *An Experiment with Time*). Retrocognition (Cf. E. F. Jourdain and A. Moberly, *An Adventure*).

CHAPTER TWENTY-TWO

G, EDUCTION AND "INTELLIGENCE"

1. INTRODUCTION.
2. *G* AND EDUCTION.
3. EDUCTION AND "INTELLIGENCE".
4. LATIN.

1. INTRODUCTION

Now we are in a position to answer a question of which the solution has been postponed from the earliest chapters. We said long ago (page 35) that the psychological nature of *g* was fully understood; and now it is time to justify that assertion. It will be remembered that not only does *g* vary quantitatively from person to person, but that some cognitive processes demand this general factor in ability more than others do. It is quite an easy matter to measure the extent to which any particular activity involves *g*;* and, when such measurements are made, it is invariably found that *in proportion as an activity depends upon eduction, so does success at it depend upon* g.

2. *G* AND EDUCTION

It follows then that to measure a person's *g* one must get him to perform eductions in the purest state possible; and that is just what the so-called "intelligence" tests, or at least the successful ones, do. In such tests the items which form the basis of the eductive processes may either be apprehended by the first noëgenetic process, or may be reproduced from the testee's own past experience. Examples of both kinds of test follow (1).

* Cf. Appendix 1, p. 290.

1 (A) Apprehension followed by relation eduction. The testee has to pick out from the group of five items (Fig. 33) the one which *least resembles* the others.

FIG. 33

1 (B) Apprehension followed by relation and correlate eduction.

i. The testee has to choose from the four figures on the right (Fig. 34) the one which best completes the "statement" on the left.

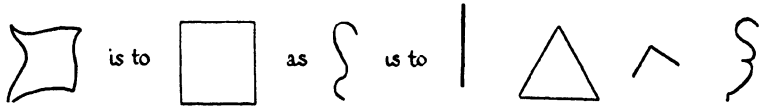


FIG. 34

ii. The testee has to isolate within the complex pattern on the right (Fig. 35) the simpler pattern shown on the left.

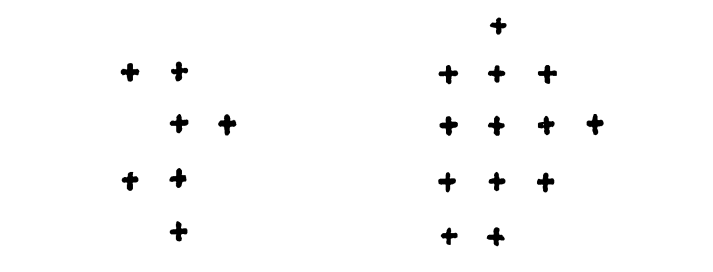


FIG. 35

2 (A) Reproduction followed by relation eduction.

The testee has to answer the following questions:

i. Are STRONG and WEAK the *same* or *different* in meaning?

ii. Are MOIST and DAMP the *same* or *different* in meaning?

iii. Which of the following *least resembles* the others?
RING—STICK—WHEEL—CIRCLE.

iv. WEALTH means *most nearly the same as* which of the following? PURSE? BANK? RICHES? WAGES?

v. Which of the following does a PEN *possess* but which a PENNY *lacks*? METAL? POINT? VALUE? DATE?

2 (B) Reproduction followed by relation and correlate eduction.

The testee has to answer the following questions:

i. WHITE *is to* BLACK *as* YES *is to*—which of the following? IF? NO? PERHAPS? WHEN?
(The processes involved in solving this problem correctly are illustrated in Fig. 36, reproducts being differentiated from educts by shading.)

ii. STATIONER *is to* PAPER *as* JEWELLER *is to*—which? PEN? DIAMOND? SHOP? INK?

iii. If *A* is *larger than B*, and *B* is *larger than C*, how is *A compared with C*?
SMALLER? LARGER? BETTER? EQUAL?

iv. If Harry's *father* is Robert's *uncle*, *what relation* is Harry to Robert?
FATHER? COUSIN? UNCLE? BROTHER?

It is processes such as these, where eduction is at a premium, that are found in actual practice and actual statistical investigation to display the highest *g*-saturations in the entire realm of ability.

3. EDUCTION AND "INTELLIGENCE"

Thus it is that "intelligence" tests are no more than assessments of eductive power; and, in so far as they are successful, they are no less than this. The good "intelli-

gence " test measures the amount of one's *g* or general cognitive ability, the undifferentiated cognitive energy

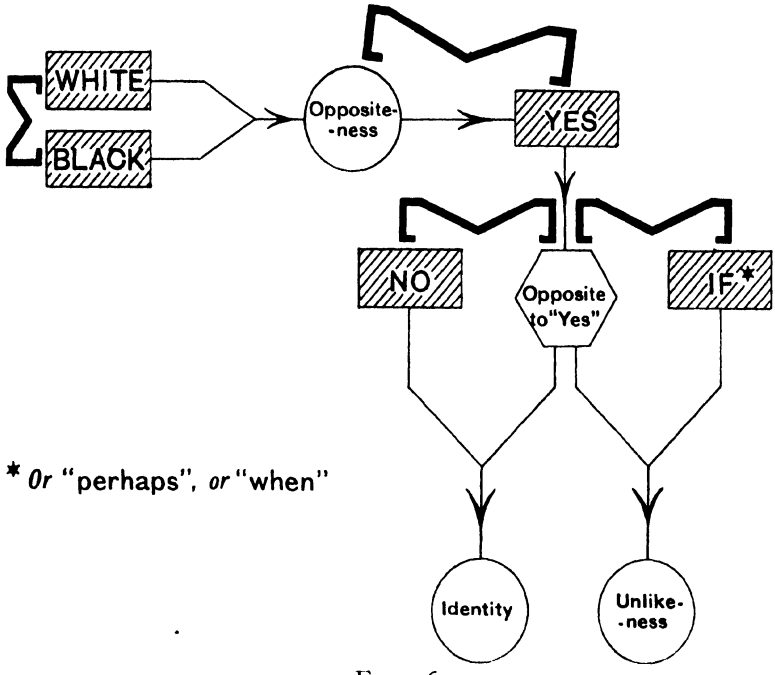


FIG. 36

which is involved in all cognitive processes to just that extent to which these are eductive in nature. Truly there is an *s* involved in educing whether MOIST and DAMP are *similar* or not; but two things must be noted here.

(1) Any normal child of twelve has learnt those words and knows their meanings; the *specific factors* in this eduction differ little among comparable children.

(2) Provided that the *s* does exist, that is, that the ideas MOIST and DAMP are familiar, then in the solution of the problem, *g* is of very much greater importance than the *s*.

Thus it is that a satisfactory " intelligence " test consists of between a hundred and two hundred separate questions in each of which *g* and an *s* is involved, but in each of which the *s* is of relatively little importance; and, anyway, is

within the compass of the sort of child for whom the test is designed. It follows that success at the test as a whole depends almost entirely upon *g*; and this is true despite the fact that a particular child here and there may fail at a particular question here and there because of an inadequate *s*.

An example of this occurred when the present writer gave the following question to some boys of thirteen and over in the East End of London.

To-day we shall have *either* hot rice, *or* apple fritters, *or* prunes, *or* chocolate. But there is no fire and no fruit. Which shall we have?

RICE? FRITTERS? PRUNES? CHOCOLATE?

Not one had ever heard of *fritters*, and so, of course, all were equally handicapped. But, in one or two hundred separate eductions any single testee's accidental superiorities and inferiorities in *s*-equipments would still tend to cancel each other out, even if they mattered far more than they actually do.

The only comment which seems worth adding is that it is a great pity that the designation *intelligence test* has not been dropped, and the term *test of eductive power*, or *test of* g, used instead. Each of the last two expressions has the double merit of accuracy and precision which the traditional one lacks; for, as a scientific term, "intelligence" has never been of any use at all. (Cf. page 18.)

4. LATIN

We have already said (page 30) that in Latin *g* is of far greater actual importance than the *s*. To this it may now be added that *g* is of greater relative importance in Latin than in any other school subject. The reasons for this are not far to seek. Translation from or into Latin requires both relation and correlate eduction on a grand scale. An

actual example provides the best illustration; this, from Lucretius, will suffice.

ME VERO PRIMVM DVLCES ANTE OMNIA MVSAE
QVARVM SACRA FERO INGENTI PERCVSSVS AMORE
ACCIPIANT

The following eductions were among those which occurred in the case of one particular translator.

Item	Reproductions	Eductions
1. DVLCES	Means *sweet* or *gracious*	DVLCES MVSAE must therefore be *gracious muses*, *sweet muses* is not so apt.
MVSAE	Means *muses*	
2. MVSAE	A feminine noun	Therefore QVARVM probably refers to MVSAE, and not to some other noun which may appear later.
QVARVM	A feminine termination	

The following (*verbatim*) notes are worth adding.

3. "ACCIPIANT is plural *and* subjunctive, which 'pulls the whole thing together'."

4. "ANTE OMNIA; means *before all things*; may qualify either DVLCES MVSAE or ACCIPIANT; but, as it is 'sandwiched between' DVLCES and MVSAE, it must refer there."

5. "QVARVM SACRA FERO. You see, these words are inseparable in metre as well as in sense."

Now, without understanding Latin quite competently it is impossible to grasp how the fact that ACCIPIANT is both "plural *and* subjunctive" "pulls the whole thing together"; but that expression means nothing at all unless it indicates that items which had previously seemed somewhat aloof now appear in meaningful relation to each other. It will be noted, too, that not only nuances (1), and relations of syntax (2) and (3), have to be educed; but that even spacial relations (4; "sandwiched between") and temporal relations (5; "inseparable in metre") may also play a part. Needless to

say translation from any language into any other requires *g*, for eductions of relations of identity-in-meaning, as well as of grammatical relations, are constantly demanded.

REFERENCE

(1) Figs. 33 and 34 are from the *Cattell Group Intelligence Scale 3*; *Form A*, Tests 2 and 4, respectively. (G. G. Harrap & Co., Ltd.) Fig. 35 is from *Psychology and Psychotherapy*, 3rd Edition, 1934; by William Brown. (Edward Arnold & Co.) The verbal examples are from *A Measure of "Intelligence" for Use in Schools*, by C. Spearman. (Methuen & Co., Ltd.)

SUMMARY OF LAWS AND COROLLARIES

The laws we have enunciated are, for convenience, collected here, together with the most important of their corollaries.

A: THE FUNDAMENTAL LAWS OF COGNITION

I. The Laws of Cognitive Factors

1. THE TWO FACTORS THEORY

Every cognitive activity proceeds *as if* success at it depended upon a general and a specific factor (*g*, and the *s*, respectively). (Page 28.)

2. LIAISON BETWEEN THE TWO FACTORS AND NOËGENETIC THEORIES

In proportion as a cognitive activity involves eduction, so does success at it depend upon *g* and not upon the *s*. (Page 183.)

II. The Psycho-Physical Law of Cognition

Neural excitation tends to be followed by sentience, that is, by the living of an experience. (Page 135.)

III. The Noëgenetic Laws of Cognition

1. APPREHENSION OF EXPERIENCE

Any lived experience tends to be followed by an immediate awareness of its characters and of its experiencer. (Page 136.)

2. EDUCTION OF RELATIONS

Awareness of any two or more items tends to be followed immediately by awareness of any relations which hold between them. (Page 146.)

3. EDUCTION OF CORRELATES

Awareness of an item together with that of a relation tends to be followed immediately by awareness of the correlative item. (Page 167.)

IV. The Quantitative Laws of Cognition

1. CONSTANT COGNITIVE OUTPUT

Cognitive output tends to remain constant in quantity though varying in kind. (Page 67.)

2. RETENTIVITY

The occurrence of any mental event is followed by a tendency for it to recur. (Page 68.)

(*I*) *FACILITATION.*

(*a*) *Of isolated events.* Mental events tend to recur more easily than they first occurred. (Page 68.)

(*b*) *Of paired events* (*association*). Mental events which occur together tend to do so subsequently with greater ease. (Page 72.)

(*II*) *INERTIA* (p). Mental events begin and cease more slowly than their apparent causes. (Page 77.)

3. FATIGUE

The occurrence of any cognitive event is followed by a tendency for it not to recur. (Page 84.)

4. VARIABILITY (*o*)

Cognitive output tends to vary continually in quantity. (Page 91.)

5. CONTROL (*w*)

The intensity of cognition can be controlled by conation and volition. (Page 100.)

6. BASIC CONDITION

The extent to which the preceding tendencies are manifested is associated with certain basic conditions, all of which vary from person to person, and some of which vary within the same person at different times. (Page 102.)

B: COROLLARIES

I. Concerning Cognitive Ability

1. THE TASK

(a) SUCCESS at any given cognitive task demands (i) the presence of a sufficient supply of *g*; (ii) the presence of an adequate *s*; and (iii) the absence of interference by any of the quantitative determinants. (Page 115.)

(b) FAILURE at any cognitive task may be due (i) to a lack of *g*; (ii) to an inadequate *s*; (iii) to interference by any of the quantitative determinants; or (iv) to any two or more of these "causes". (Page 115.)

2. THE PERFORMER

The presence in a person of the two factors *g* and *s* makes for, and will secure, success in the long run; but the quantitative determinants may, on any particular occasion, impair the functioning of *g*, or of the *s*, or of both, and so bring about failure in the activity, even to those who are really best equipped for it. (Page 115.)

II. The Anoëgenetic Processes of Cognition

1. CLEARNESS VARIATION

Items in awareness are constantly changing in clearness. (Page 123.)

2. REPRODUCTION

Items become cognized in a manner which postulates their having been cognized before. (Page 124.)

PART FIVE

THE UTILIZATION OF KNOWLEDGE

THE PROBLEM

It must have been noted that this work differs in one important respect from older and more orthodox ones which also deal with the psychology of cognition. So far no chapters have been devoted to such specific topics as those of perception, reasoning, memory, imagination, and the like. In short, we have ignored the traditional "faculties" which even to-day serve most psychologists as a skeleton to be befleshed with their chosen doctrines of cognition. We have spoken instead of the factors, the quantitative determinants, and the noëgenetic laws of cognition; and we have regarded these only as fundamental. IT NOW REMAINS TO SHOW THAT THESE NEWER IDEAS ARE ADEQUATE TO DESCRIBE THE FACTS WHICH ARE COMMONLY TREATED UNDER THE OLD "FACULTY" HEADINGS; *and it is to this problem that Part* 5 *is accordingly devoted.*

But, before we undertake this task, a word of warning is necessary. It would hardly be possible in a book of this type to deal fully with all the problems which the "faculties" present; the result would be at once too lengthy and too abstruse. In the pages that remain no more is attempted than a sketch of the lines of approach which the factor and noëgenetic theories suggest for the solution of the more obvious problems. Sufficient detail is given, it is hoped, to enable the reader to grasp how the fundamental "givens" of cognition are related to some of the gross products of cognition. We shall be able to see how

*the apprehensions, and the educed relations and correlates, which are the basic elements of knowledge, co-operate with each other and with the quantitative determinants, giving rise to the more complex items of knowledge which are the traditional study of psychology. For more exhaustive analyses of the "faculties", reference must be made to Spearman's original works; and to the records of the many experimental investigations which these have inspired.**

* It is to be noted that *attention*, *confluence* and *association* have already been dealt with. (Pp. 125, 154 and 163, respectively.)

CHAPTER TWENTY-THREE

PERCEPTION

1. The Role of Sensory Apprehension.
2. The Role of Relation Eduction.
3. The Role of Correlate Eduction.
   (*A*) The problem of meaning.
   (*B*) The traditional view.
   (*C*) The acceptable view.
4. Further Examples of Noëgenetic Supplementation.

1. THE ROLE OF SENSORY APPREHENSION

In so far as perception is dependent upon sensation and reproduction we have begun its examination already (chaps. 17 to 19). But perception connotes something other, and more, than mere sensation and associated reminiscences; something that may roughly be termed "meaning". A sensation, say, a visual one of blue, has in itself no meaning. It only evokes by the first noëgenetic process (that of the apprehension of experience) a bare awareness of its quality of blueness and of its intensity and spacio-temporal situation. But a percept of blue has meaning; signifying perhaps the sky, the sea, a curtain, or a distempered wall. The problems of perception, then, are first: How does all this meaning, which supplements sensory experience, arise? And, secondly: Of what does it consist?

It seems that our cognitions of simple sensations are essentially dynamic, and that they become modified in consciousness in two distinguishable ways. These two ways are concerned respectively with the different characters of quantity and quality inherent in the sensation itself. Sensations tend, in the first place, to undergo a quantitative

increase; that is, they become more intense. In the second place they tend to become more determinate; that is, to partake more obviously and decisively of that peculiar quality which marks them off from all different sensations. These two changes are not simultaneous, although to naïve observation they usually coalesce and, if noted at all, are noted as a single change towards increased clarity of the cognition.

Although this distinction between intensity and determinateness may seem rather subtle and academic, it can easily be recognized in ordinary life, in which, in Spearman's words, "there appear to be numerous cases where the intensity is great, although the determinateness is small. Such are afforded by the apprehension of new notions; or even of old ones, if sufficiently difficult. Fatigue, also, can reveal striking contrasts in this respect; overnight, certain items may be apprehended with great, even obsessing, intensity, and nevertheless obstinately remain very indeterminate; on the following morning, these same items may arise in consciousness no more intensely than before, but now with the determinateness of a line engraving. Similarly, when a rather subtle argument is examined over and over again until understood with facility, the later rehearsals of it may quite well fall short of the earlier ones in intensity, although surpassing them in determinateness" (1). This, again, is very apparent when we compare a present cognition with a previous one. To take an example from music: the pitch of a note heard now may be compared with that of another heard yesterday. The determinateness of the remembered note may, with a highly musical person, be perfect; but in point of intensity it may be quite unintrospectible. It is merely "subconscious" in that sense of the term which includes all those former cognitions which, while not now present to consciousness, are yet available for recall.

2. THE ROLE OF RELATION EDUCTION

It is, however, the increase of determinateness rather than that of intensity which concerns us here, for this is the agency by which we are enabled to pass from the first to the second noëgenetic process; from mere apprehension to eduction; and this transition seems to be essential for true perception. To educe a relation from between two items means that they have become differentiated in some way; and clearly this cannot occur before each is adequately determined. This may be illustrated by a simple experiment in which two lines almost equal in length are shown together. If the exposure is very short the relation of difference will not be educed, though the lines themselves may be cognized with considerable intensity.

The first stage of perception is, then, the apprehension of some cognitive experience; and this develops by way of an increase in the clarity of the resulting cognition. Further, this clarity has a two-fold aspect. It is due in the first place to the presence of the cognition in sufficient intensity; and in the second it is due to a more slowly developing increase in the determinateness of the cognition. As this second process continues, opportunity is afforded for the cognition to become differentiated from others; and this takes place when, by the second noëgenetic process, a relation is educed between them. It is by virtue of this last process that the discrete presentations, say, of colour and black-whiteness experienced when we look out of a window, are grasped as a single unity and not as a patternless and meaningless mosaic of visual sensations.

This awareness of items as related to each other constitutes, then, the second phase in perception; and it tends to evolve automatically and immediately from the first phase of mere

apprehended sensations by virtue of the second noëgenetic process of relation eduction.

3. THE ROLE OF CORRELATE EDUCTION

(A) The problem of meaning. But in ordinary perception more occurs even than this. If you ask me what lies on the table beside me as I type these lines, I should not answer, " An aggregation of chromatic and achromatic sensations, mutually related in space and in time " ; I should answer quite simply, " A book ". Indeed, one does not normally note either sensations as such, or relations between them ; though either can if we wish be abstracted and contemplated *per se*. But my answer *a book* would strictly speaking be untrue ; for, at the best, I cannot see more than three of the six faces which the book certainly possesses. Further, by the expression *a book* I mean much more than just something with six sides : my reply rules out, for example, cigarette boxes, which also possess this particular complex of characters. By *a book* I mean something with six sides, containing sheets of paper which are fastened in a special way and which serve at least one of a limited number of definite functions, and also something which has a characteristic weight and will evoke characteristic and recognizable tactile experiences if I handle it. The inevitable inference is, then, that my past experience of books has played some part in my present perception of this one ; and, by supplementing in some way the spacially-related sensations given now by the first two noëgenetic processes, it has rendered them meaningful. The nature of this supplementation of present by past experience demands some discussion.

(B) The traditional view. Traditionally it has been held that the visual sensations emanating from the three seen sides of a book reproduce associatively either an image or

an idea of the remaining unseen sides, and also of the other sensory phenomena to which books typically give rise. In other words, through previous handling of books, I have become acquainted with all their characteristics; and when on this occasion I become aware of some of those characteristics, the others will be associatively reproduced.

Now such a view is fairly obviously inaccurate, and this is especially clear when the thing cognized is novel. Let us consider an actual example in which some elements in an otherwise familiar situation are sufficiently novel to preclude the possibility that reproducts from past experience can wholly account for the meaning of the present one. The book shall be the particular edition of Chekhov which now lies closed beside me. The binding is of maroon leather, but it differs, fortunately, in almost every respect from that of any other book I have ever handled. The front is embossed with a symmetrical design in which faces with vermilion whiskers and green hair surround an irrelevant shield and coronet. The whole is further graced by a hexagon, an ellipse, four large triangles, six small circles, and ten assorted scrolls. The more offensive details are emphasized quite impartially either in vermilion, green or gold. The spine presents a fairly accurate scale drawing of a garden trellis, the gaunt heads of twenty-two trunkless daisies glaring one from the centre of each hole. All this, of course, is in gold. Now it may be that in early youth I once saw such a book and that recollections of it have very properly been repressed. But I think not. I think it certain that when a few months ago I first saw this book *and cognized it immediately as such*, that feat owed little to mere reproduction; for not even in a nightmare have my experiences ever been such that they would cohere with the visual sensations to which the front and spine of my Chekhov give rise.

(C) The acceptable view. What happened was that from the utterly novel sensory experiences provided by the visible sides of the book, I was able to *e*duce a familiar system or network of spacial relations (Fig. 37), namely, those which

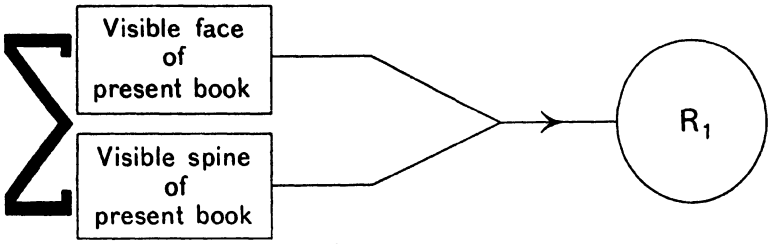


FIG. 37

the front and base of every book I have ever handled bear to each other and to the spine. This network of spacial relations then *repro*duced associatively not bygone experiences—not one of which could have fitted the present situation even approximately—but a further network of yet other equally familiar relations (Figs. 38 and 39). These, of

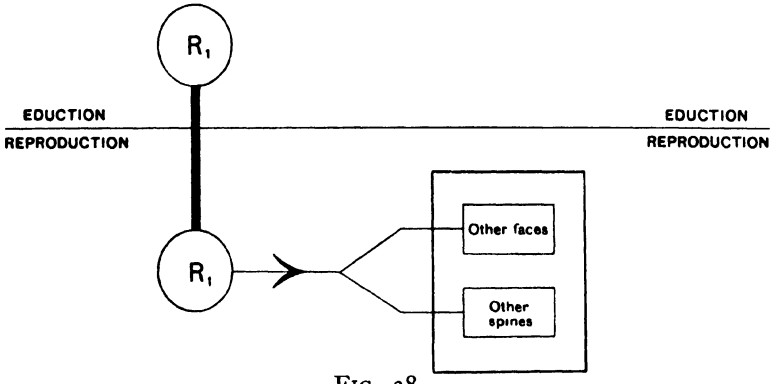


FIG. 38

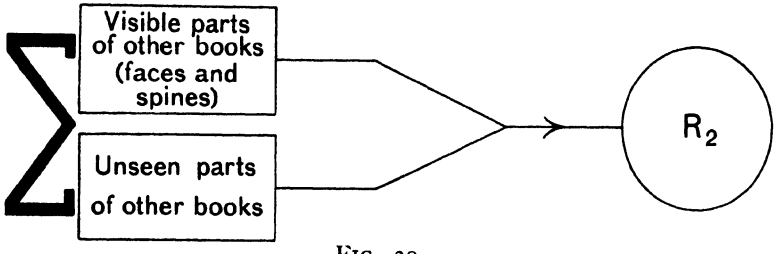


FIG. 39

course, were also mostly spacial; including in particular those which the visible sides of other books have inevitably been found on exploration to bear to their own unseen sides. Now the third noëgenetic process comes into play. The reproduced relational system, together with what is actually visible, generate the idea or image of a correlative set of unseen sides which is wholly new and uniquely adapted to this particular partial representation (Fig. 40). The entire sequence of events is depicted in Fig. 41.

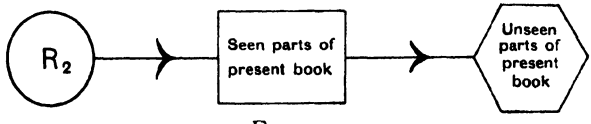


FIG. 40

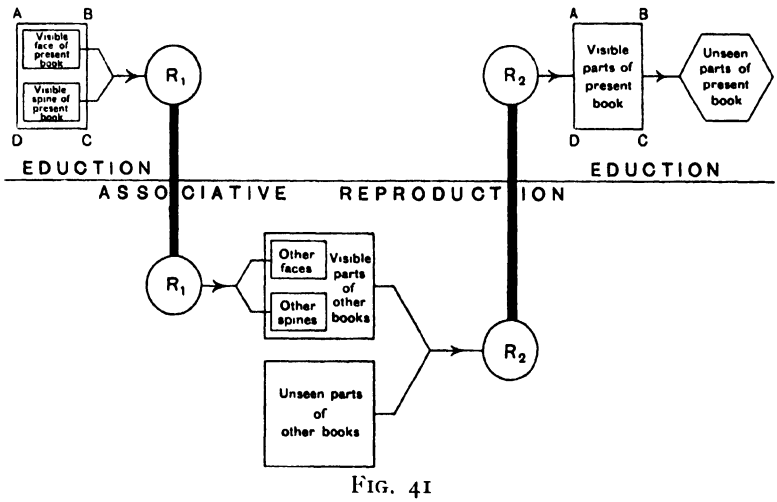


FIG. 41

The two rectangles A B C D represent, of course, the *same* experience at earlier (left) and later (right) phases of its acquiring meaning.

The important point is that this supplementation of what is given by the first two noëgenetic processes is no mere *re*product, or resurrected experience; for such could never make a novel presentation meaningful. It is a brand new mental *con*struct which is perfectly organized to complete what is given to perception on this particular occasion,

unique though this may be. Associative reproduction truly plays its part, but only the subordinate one of providing from similar complete experiences in the past a system of relations which can be applied to the present partial experience. The actual supplementation, ideal or imaginal, is the correlate which these relations and these presentations conjointly generate. Thus it may even be something which wholly transcends all actual or possible former experience, as when a small boy sees a picture of an ogre for the first time, and rightly cognizes it as a quasi-human monster.

4. FURTHER EXAMPLES OF NOËGENETIC SUPPLEMENTATION

In other circumstances noëgenetic supplementation of present sensory experience makes us aware that the things which have given rise to them are animate like ourselves. We find that certain objects around us appear to be conscious; and that they think and strive and will and feel, as we do. In Spearman's words the following are, respectively, the traditional and acceptable views of this phenomenon. "The sight of external gestures is asserted to evoke in the mind of the perceiver the emotions by which such gestures were accompanied formerly in his own case. Similar associations are alleged to be established with expressions other than gestural, such as the sparkling of the eyes, the lowering of the brows, and so on. Now, all this must here be rejected as decidedly incorrect. The characters of consciousness expressed in gesture or countenance are notoriously far from being strictly confined to the previous experiences of the person perceiving them. On the contrary, they may appear to him most strange; in no instance, probably, are they *precisely* the same as any previous experience either of himself or even of anyone else. On picking out the con-

stituents that really do remain constant in the impressions conveyed to any perceiver by the facial expressions of others —and that therefore do admit of being explained as bare reproducts—these constituents prove always to be relations only. For example, there is usually a quantitative relation between the brightness of the eye and the vivacity of consciousness. Hence, when once any degree of brightness has been apprehended and the said quantitative relation has been reproduced, then the corresponding degree of vivacity may come to awareness as the correlate ; this can happen whether or not such particular degree of vivacity has even been experienced or mentally presented before.

" But if this be then the form of the operation of perceiving conscious beings as such it is after all no other than that already described in the case of the book. There is again an intimate blend of two processes, of which the first is the reproduction of a system of relations, while the second is the eduction of a correlate " (2).

REFERENCES

(1) NP, p. 160.
(2) NP, p. 247 *et seq.*

CHAPTER TWENTY-FOUR

THE INTELLECT

1. CONCEPTION.
   (*A*) By disintegration.
   (*B*) By fusion.
   (*C*) By free eduction.
2. JUDGMENT.
3. REASONING.

The processes of conception, judgment and reasoning are usually classed together as "intellectual". This is convenient, as it enables them to be distinguished from those of perception; and this distinction is commonly regarded as fundamental, largely because we must admit to sharing the power of perception with lower animals, whereas intellectual activities are often claimed as specifically human. None the less we shall see that the facts and processes of conception, judgment and reasoning are all explicable in the terms we have been employing hitherto. We shall find that, like the perceptive process, intellectual ones are at basis noëgenetic; and thus, in this sense, the traditional distinction between the two kinds is by no means fundamental.

1. CONCEPTION

Spearman defines a concept as "any item of cognitive experience that by verbalization has become relatively stable" (1), and he distinguishes three ways in which we come to form them.

(A) By disintegration. From a very early age we come to isolate mentally certain characters from the total situations in which they were experienced. Such are the ideas "hot",

" round ", " angry " and " good ". The process is a double one. In the first place it depends on the tendency to increasing determinateness possessed by all percepts, which affords scope for their more precise differentiation (by relation eduction—Cf. page 146 *et seq.*) from others; and, in the second place, the actual disintegration of the original total percept—or the disruption of the particular character from it—is due chiefly to the constancy of cognitive output. The dominant character tends to monopolize *g*, while other characters, say, those of " heavy ", " brown " and " thick ", tend, if perceived at all, not to be present in consciousness with the same intensity or determinateness. Thus the character " hot " might tend to become disintegrated from the rest of a percept; and so would be in a fair way to becoming conceptual.

(B) By fusion (2). Concepts which represent a whole class of individuals similar in some respect arise in a different way. Such ideas as those of " metal ", " plaything " or " dwelling " seem to be complex ones in which both imagery and purely notional, or imageless, awareness play a part. The imagery may be fragmentary and inconstant; to-day a chance hearing of the word " plaything " may conjure up a vague and fleeting image that somehow seems to " mean " a child on a scooter; to-morrow that same word may arouse an image—perhaps vivid, perhaps as nebulous as before—of a ball, a rattle, a doll, or a game of marbles. But besides such superficial, evanescent and frequently irrelevant shadow-shows of the mind, which are inevitably specific in that they must refer to this or that particular plaything on some particular occasion, there is an additional and basic imageless notion of *plaything-in-general*. This is not, as has been alleged, the abstract common element in all the playthings one has met with; and still less is it any average of

them all. It is rather a fusion of them all, in which their differentiæ seem somehow—though but faintly and vaguely —inherent.

Such fusion is readily explicable. The presentation of many diverse objects of the same general class tends to result in the eduction of relations of similarity between them with respect to their common element, and of relations of unlikeness between some of the characters in respect of which they differ. But it is clearly impossible that one could ever educe all the thousands of possible relations of dissimilarity between, say, a rattle and a doll; and the fact that cognitive output tends to be constant sufficiently explains why, in actual fact, we do normally become aware of but few of these relations. What may well be termed the "collective consciousness" of a particular class of objects will therefore partake of the nature of a fused notion, in which the several individuals are but imperfectly differentiated.

(C) By free eduction. The third and last kind of concept arises as the direct result of eduction. It is distinguished from the two former types in that it is always something new—a mental construct—whereas the others are but disintegrations or fusions of things presented to perception. This third sort occurs only when the educed relation or correlate tends to be isolated or freed mentally from the items which were related. The tendency is then for it to have a name attached to it, and it comes to function as a conceptual unity. "Pre-eminent instances", Spearman says, "are the chief concepts of the sciences. Thus, mathematics evolves, by laborious eductions one after the other, such concepts as those of 'number', 'contiguity', 'infinity', 'function', 'exponential', 'series', or 'aggregate'. Similarly physics has produced its 'molecules', 'electrons', 'atoms', 'ether',

together with its ' potential ' and ' actual forces '. Biology has brought forth, in particular, its ' evolution '. And so on with the other sciences " (3). That is to say, some relation and some related item, both of which are already known, give rise to a correlative item which was previously unknown. For example, certain relations detected in matter which is large enough to be perceptible are applied to matter which is wholly imperceptible, and thus such concepts as those of molecules and the like are educed. Spearman, continuing, says that another " instance of special importance, both historically and philosophically, is the keenly disputed concept of the infinite. From our present standpoint this may readily be seen to consist in ' that which bears to the finite the relation of oppositeness '. Similarly, one of the concepts of God is ' that which bears to the cosmos the relation of adequate ground ' " (4).

2. JUDGMENT

Judging is commonly held to be an intellectual process bridging the gap between conception and reasoning ; but the term is used loosely in at least three different ways. Sometimes judgment is the name given to the process of combining concepts, and, in Locke's words, of " perceiving their agreement or disagreement ". At other times judgment is taken to be the mere acquiescence in, or rejection of, a proposition. And, lastly, the term is frequently employed as a synonym for mere opinion. This last usage will be rejected here for reasons which will appear in a moment ; and we shall confine ourselves to the task of reconciling, with the aid of the customary principles, the second view with as much of the first as is true.

In any process culminating in that type of volitional acquiescence in, or rejection of, a proposition which can

be termed a judgment, there are two preliminary stages. First, there is an examination of the terms involved; and, secondly, the eduction of a relation between them. Only then can the volitional fiat ensue, and a proposition embodying the relation is accepted as the judgment.

But two points should be noted. First, that the terms between which the relation is educed need not be conceptual. We can judge that this grey is darker than that, when both items are perceptual; or that this taste is sweet, when the relation of attribution is educed between a percept (the taste) and a concept (sweet). In the second place it is also to be noted that the initial phase of exploration may be curtailed, particularly by facilitation due to previous repetition, to vanishing point; whereupon we enter the realm of purely habitual judgment. Here the relation is reproduced associatively rather than educed, and the volitional acceptance tends to follow equally automatically. This happens when, without slackening the speed of a car, one "judges" that a gap discerned in the traffic ahead is sufficiently wide. Not wholly dissimilar is the type of pseudo-judgment which is based on authority. From the very first a child's experiences are constantly being anticipated verbally by the adults around him; one of the earliest lessons he learns is that of an uncritical trust in authority; and this too often remains throughout life. Neither in the case of habitual acquiescence nor in that of the uncritical acceptance of authority is true eduction involved. But in both cases the final phase, that of volitional acceptance, is the same; and it is this that probably accounts for the fact that they are commonly mistaken for true judgment.

3. REASONING

Traditionally, reasoning has been typified by the syllogism, the time-honoured example being:

MAJOR PREMISE	All men are mortal.
MINOR PREMISE	Socrates is a man.
CONCLUSION	Hence, Socrates is mortal.

Now such a formal process is very seldom, if ever, explicitly performed in ordinary speech or writing; it is rather an academic test which can be applied to check the accuracy of the much abbreviated eductions and reproductions which people more commonly make. Of these we have already had many examples, particularly in Chapters 21, 22 and 23.* Others will be given incidentally from time to time. One point is, however, worth noting in passing; namely, that overt syllogistic deduction necessarily involves the eduction of a relation of evidence between the two premises on the one hand and the conclusion on the other (5).

REFERENCES

(1) NP, p. 266.

(2) Spearman now prefers the term *fusion* to that of *confusion* used in NP, p. 268 *et sqq.*

(3) NP, p. 273.

(4) NP, *loc. cit.*

(5) Cf. NP, pp. 289-290.

* *N.B.* Chap. 22, § 4.

CHAPTER TWENTY-FIVE.

MEMORY, RECOGNITION AND IMAGINATION

1. MEMORY.
2. RECOGNITION.
3. IMAGINATION.
   (*A*) Pretence.
   (*B*) Absurdity.
   (*C*) Realisation of the absent.

1. MEMORY

The term " memory " may be legitimately used to describe three classes of phenomena. Two are alike in including the recall of former personal experiences, the awareness that they are personal, and the localization of them in a past-time perspective ; but they differ in that the experiences in the one case are those of one's own personal acts and states, and in the other those of external things previously perceived. The third class of phenomenon which may properly be included under the head of memory is that of the recollection of information about things. This differs from the other two types in that " the reference to the person's own past experience (and even to pastness at all) may sometimes at first sight incline to be dubious. Neither the one nor the other sort of reference would appear to be in consciousness quite indispensably when . . . remembering facts about the sources of the Nile.

" Still, whoever believes such facts will almost always, if not actually evoke, be always able to evoke some awareness of having in the course of his own previous experience assented to them. And as for the extreme case where a

proposition is indeed believed without either any such actual or indeed revivable notion of ever having learnt it, . . . to such a totally irresponsible credence as this the title of remembrance is no longer properly applicable " (1).

A necessary prerequisite of all remembering is, of course, the retention of the state or thing or information to be remembered ; and retentivity has been regarded here as one of the fundamental " givens " of psychology (chaps. 9 and 10). The problem remaining, then, is to account for the localization of what is remembered at some point in a personal past-time perspective. The problem may be stated alternatively as follows : When we recognize a past experience as such, how do we become aware of its pastness ? (Cf. p. 128.) We have already found that in apprehending any particular experience we tend to become aware of its temporal character ; that is, experiences in process of being cognized inevitably possess a character of *nowness* (chap. 19). Hence it is that, between any two cognitive experiences which are not simultaneous, a relation of succession tends to be educed by virtue of the second noëgenetic process. From the relation of succession to that of pastness is but a single and a simple step. " Let *a*, *b*, *c* . . . *z* denote consecutive instants of experience. Then the sequences *a-b*, *b-c* . . . *y-z* are apprehended as conjointly constituting the total period *a-z*. And on reaching *z*, this is perceived to be ' now ' " (2). The relation *before-now* tends then to be educed between the period *a-y* on the one hand, and the instant *z* on the other ; and it is thus that the notion of pastness arises. A further process, however, comes into play here. We have already seen that an experience which has occurred tends normally to perseverate. But from what has just been said it is apparent that it does so as an idea which is continually receding pastwards. " In proportion as the perseveration

subsides, the presentation naturally becomes fainter; and after a very few seconds it sinks below the limen. There is seemingly no further 'immediate' remembrance" (3). When recollection does take place what happens is that this now subconscious experience is intensified at the expense of other contents of consciousness, which it replaces.* Thus remembering is of the nature of an inward observation, and we must take it that everyone "potentially carries about with him a comprehensive, though subconscious, presentation of his whole past experience" (4).

2. RECOGNITION

The recognition of present experiences, that is, the knowing of something as similar to, or identical with, something known previously, offers no difficulty of explanation. It consists, as the definition implies, of the eduction of the relation of similarity or identity between what is perceived now and what is remembered. There are thus two steps involved. First the present experience must associatively reproduce a memory of the previous one (chaps. 17 and 20); and, secondly, a relation either of similarity or of identity must be educed between the recollection and the perception. Not until this occurs can the latter be recognized. It is, however, important to note that, provided the "memory" is sufficiently determinate, its degree of intensity may be extremely small† without inhibiting the eduction of the relation. This occurs with the present writer whenever he switches on the radio in the middle of a piece of music which he then recognizes as familiar. Recollections of previous hearings of the same piece are never of noticeable intensity; though they may be sufficiently determinate for fairly subtle differences in tempo and in orchestral balance to be detected.

* *N.B.* constancy of cognitive output and conative control. † Cf. p. 196.

3. IMAGINATION

By " imagination " is meant roughly the creative power of the mind. In perception and in memory the mind is commonly held to be limited by what respectively is, or has been, presented to it ; while in its intellectual and imaginative activities the mind is held to transcend experience. But these last two are regarded as differing fundamentally in another respect, for it is of the essence of intellectual activity that its products should correspond with realities more ultimate even than those with which perception acquaints us, whereas in imagination the mind reaches out beyond all reality and creates of itself—out of nothing, and in defiance of all calculable laws—products which, in turn, need correspond to nothing outside themselves. Such at least is the popular view ; but many professed psychologists have rejected it entirely. They deny any true creativeness to the mind in its imaginative activities. The wildest of its supposed imaginings are held by them to be nothing more than former cognitive elements brought together in novel combinations ; and the process by which this occurs, far from being one which breaks all known laws, is held to be associative reproduction and no more. Both these views will be rejected here ; and, in the process of developing what is held to be a more satisfactory one, the chief types of imaginative activity will be examined in turn.

(A) Pretence. Quite early in life a child's play tends to take on an imaginative form. The little girl with her doll, and her little brother with his punch and bell and tickets, are alike in carrying through " in imagination " roles which they have seen performed by adults. In later years imagination tends to become divorced from both experience and egoism. Play turns to day-dreams of boundless wealth and power ;

and finally to fiction, in which stories are heard or read in which the central role is played by someone other than the reader. The chief process involved in these examples of imaginative activity appears to be one of correlate eduction. Relations which have been educed from a familiar system of ideas are transferred to other items in another context, and the imagined idea or activity is no more than the resulting correlate. The little girl has appreciated mother in certain characteristic relationships to baby, and forthwith applying some of these relations to herself, " mothers " her doll. The latter may, for that matter, seem to an adult to be merely a dirty and inadequately clad clothes-peg ; for, from the point of view of the child, the correlative idea of *herself-as-mothering* may be of far greater importance than the particular object which serves as the medium for expressing the idea in action.

(B) Absurdity. In the pathological sphere, and in dreams, the same process of educing correlates seems to be at work. In the case of the dement who believes he is the Pope, or that coloured rats are crawling round the room, an obsessive relational system is applied either to the self or to the perceptual effects of alcoholic stimulation of the nerves. As far as dreams are concerned, Spearman's comments themselves are best quoted. " The most simple and most easily interpretable [dreams] are such as have derived their characteristic features from experimental stimulation. The following instance is illustrative : ' A person over whose mouth and nose I had laid a light silk handkerchief, awoke after a considerable time with a cry of terror and with much sweat on his forehead and the palms of his hands. He had dreamt that he had been buried alive and had awoke in his coffin ' (5). Even the more elaborate theories of dreams, such as the Freudian and Jungian symbolism, would appear to need . . . a reduction of the dreaming to the same basal process of

correlate eduction. Take, e.g. the reported dream sentence, ' Follow the grave-diggers ' (6). The psycho-analytic interpretation of this sentence was that the dreamer, after being obsessed by certain tragic remembrances, had arrived at the belief that ' grave-diggers are those who in burying the dead do a public service. . . . She, too, must get rid of her symbolic corpses, these dismal emotions that she drags about with her ' (6). Here, as may easily be seen, the general form of the cognitive operation is . . . as follows :

" *Dismal emotions* should be to *me*,
" as *the dead* are to—*the grave-diggers* " (7).

This example of the eduction of a correlate should be compared with the similar ones already given (chap. 22).

(C) Realization of the absent. The power of " putting one's self in another's place ", of realizing the effects of an unfamiliar occurrence in a remote part of the world, or foreseeing the outcome of a certain course of action, or the probable results of an innovation, are all commonly ascribed to the imagination. From what has gone before there should be little difficulty in seeing that, once again, correlate eduction is the basis of such imaginative flights. To " know what I should do if I were in your place ", or to foresee the possible consequences on an unfamiliar golf course of driving a ball straight towards the pin whose top is only just visible above a rise in the immediate foreground, requires no more than the application of an associatively reproduced system of relations to given items. What is " imagined " is nothing but the resulting correlate.

The following example is one of a type which obviously has very great practical importance, and is worth careful consideration on that account. A report in to-day's paper says that " The entire grain-producing region [of the Middle Western States of the U.S.A.] is gripped by dust storms, a

heat-wave, and the most seriously destructive drought for a generation. . . . An area 1,500 miles long and 900 miles broad is being blanketed by a thick pall of heavy dust. The cloud is over two miles high " (8). To form an even moderately adequate idea of such a situation as this demands reproduction and correlate eduction (as well as conative control) on a grand scale. It is certain that if he were to read such a description in the ordinary way, the " imagination " of the present writer at least would fail to function almost completely. Most people probably read such passages without experiencing a hundredth part of the emotional response which would inevitably follow a successful effort to grasp the realities depicted.

In this instance one who is wholly without personal knowledge of the district involved has first to reproduce recollections of information about it; its vastness, its flatness, and its mile after mile of grain. In my own case these essential but rather academic details can only be made more real by first recollecting the biggest and flattest district I know from personal experience, the plain of Belgium, Holland and North Germany. Then, by a process of combined reproduction and correlate eduction which is extremely difficult and by no means completely satisfactory, I try to form an idea of a similar tract of country extended to many times its extent and wholly given over to field after field of grain, each stretching far into the distance. The difficulty is, of course, with the size. I can easily " imagine " an area, say, four times the size of the open pages of this book; such a correlate is well within experience, and is easily educed and recognized as adequate. But to think of an area even only four times the size of one in which I spent a few weeks' holiday-making is far more difficult. The correlate which should result from applying the relation *four-times-as-big-as* to an initial item

already so vast that it almost eludes the cognition which seeks to embrace it as a single whole, is altogether too far beyond my experience to become clear and stable. I can do rather better by applying the additive relation *as-big-again-as* twice in succession; and better still by substituting time for space, thinking of hours spent in trains instead of tracts of country. Now come the dust storms, the heat-wave and the drought. The first, again, is outside my experience; but dense fogs, which are frequently within it, give some help. I do know what changes are wrought by fog in a familiar landscape; and by correlate eduction I am able to think of the unfamiliar one subjected to a similar change. And so with the heat and drought.

The practical point is that in the already partly collectivized life of to-day many of one's actions should be largely modified by a consideration of their effects on others. The importance of sympathy and imagination are usually and rightly stressed in this connection. Sympathy is a complex orectic factor, and as such its discussion lies outside the scope of this book. But imagination is a cognitive phenomenon; and, as such, demands *g*, sometimes to a considerable extent. It follows that many people, both inside and outside the ranks of professed politicians, would be quite incapable of imagining the probable consequences of, say, some proposed reforms. Even if they had adequate data upon which the many elaborate eductions necessary could be built, it seems likely that most people possess insufficient *g* to perform them.

Another point is worth making here. It would seem possible on some occasions when the eductive process which should be made is for some reason difficult, to substitute instead a kind of double reproduction. On the same page as the paragraph just quoted the newspaper in question has

a review of a book. The following passage occurs. " He [W. G. Grace] began with 344 against Kent for the M.C.C. at Canterbury (his side were ' following on ! ') ; he broke his bat and borrowed one that was too small in the handle and hit harder than ever." In seeking to " imagine " this incident the present writer found himself merely adding mentally a reproduction of a small bat to one of W.G.. This, of course, is just what all imaginative processes have been held to consist of. But it would seem to be the lowliest type of all ; scarcely, perhaps, deserving the name. It serves, however, when the truly creative eductive processes are baffled.

This brings us to the last point of all. Some eductions are quite impossible, and one's " imagination " is powerless in their august presence. An example can be found in another part of the article last quoted. " Every day a new ' record ' is set up in cricket. . . . The imagination sees the daily store of runs mounting higher and higher like a dump." The only comment possible on this stimulating psychology seems to be a flat contradiction. The " imagination " does nothing of the sort. It could not, even if it existed, and there were any reason whatever why it should. To me, a " store of runs " is in itself unthinkable. One that is " mounting higher and higher ", thereby resembling " a dump ", is not merely unthinkable, it is even unbelievable. This, like *sooner-than-red* and *fatter-than-Tuesday*, belongs to the type of eduction which is quite impossible. On examination, literary metaphors appear not infrequently to belong to the same type.

REFERENCES

(1) NP, p. 307 *et seq.*
(2) NP, p. 319.
(3) *Loc. cit.*

(4) NP, p. 325.

(5) Spitta, *Die Schlaf- und Traumzustände der menschlichen Seele*, p. 278.

(6) C. Long, *Psychology of Phantasy*, p. 115.

(7) NP, pp. 330-331.

(8) *The Manchester Guardian*, Saturday, May 12, 1934.

PART SIX

EVALUATION

THE PROBLEMS

Not long ago I was spending a holiday in a city which shall be nameless. I had dutifully seen the conventional sights; and, I readily own, had found them far above my expectations. I made my way to the University, was directed to the Department of Psychology, and immediately lost myself in a maze of winding stairways and drab stone passages. A very courteous and sympathetic undergraduate took pity on me, led me to my destination, and forsook me there. Not until a few minutes ago, when I saw in the subsequent events the possibility of the present illustration, has my regret for this last act of hers been appreciably mitigated.

I inquired for the Professor, and introduced myself to him as a student of Spearman's who would like to see over the laboratories if someone could be found with leisure to take him round. The Professor was cordial, and sought a pilot. Finding none, he was kind enough to appoint himself to the post; and we set off together. Ten minutes later I was standing on a table in a darkened room, putting a plug into an electric light socket. Half the Professor was under the table, doing things with the other end of the flex. He spoke quite spontaneously. "Of course, Mr. Thomas", he said, "you realize that we don't attach as much importance to Professor Spearman's theories here as they do in London."

Now, that remark, uttered by a Psychologist of repute, surely

demands consideration. We have examined Spearman's theories sufficiently to grasp their nature and their scope. If our estimate of them, favourable or otherwise, is to be more than a mere matter of geography—varying inversely, shall we say, with our distance from London—there are three questions to which answers must be found. Put somewhat colloquially they are these:

(1) DO THE FACTOR AND NOËGENETIC THEORIES RING TRUE?

(2) IF THEY DO, THEN, DO THEY GET US ANYWHERE WORTH WHILE?

(3) ARE THERE NO BETTER ALTERNATIVE THEORIES?

CHAPTER TWENTY-SIX

SOME CRITICISMS DISCUSSED

A : THE TWO FACTORS THEORY

1. INTRODUCTION.
2. CONTRASTED VIEWS.
3. A CRITICISM WITHDRAWN.
4. EARLIER DATA.
5. A SUGGESTED TEST.
6. THE COMPLEXITY OF *g*.
   (*A*) *G*, conation and volition.
   (*B*) The indeterminacy of *g*.
7. A FURTHER POINT OF VIEW.

B : NOËGENESIS.

8. A COMMENT ON THE FIRST LAW.
9. A COMMENT ON THE PRESENT OUTLOOK.
10. THE RELEVANCE OF RELATIONS.
11. A DIGRESSION ON HUMOUR.
12. EDUCTION : IMPLICIT AND EXPLICIT.
13. A FURTHER POINT OF VIEW.

C : THE QUANTITATIVE DETERMINANTS

14. EDUCTION AND VOLITION.
15. CONSTANT OUTPUT QUESTIONED.
16. AN IMPORTANT CAVEAT.

A : THE TWO FACTORS THEORY

1. INTRODUCTION

Let us begin by considering the factor theory. *Does it ring true ?* We said at the outset (page 27) that this theory stands or falls solely by the validity or invalidity of the statistical theorems and deductions it involves. Indeed, the factor theory is, in essence, a statistical one ; and not in the least psychological. Spearman could have evolved these same

methods and theorems even though he had lacked all interest in, and knowledge of, psychology. The validity of the conclusions cannot be contested by the psychologist as such. Criticism can only come from the statistician; and it is hardly conceivable that, if he decrees it to be satisfactory at all points, the psychologist would find it in any way less so.

This seems to the present writer to be rather an anomalous, a paradoxical, situation. All the psychologist can do is to observe. He passes his observations on to someone who need have no training at all in psychology. The latter tells him that each of the observations must have had a double derivation. With the mathematician's habitual and picturesque verbosity he labels one source *g* and the other *s*; and leaves to the psychologist the task of interpreting these symbols into his own jargon as best he may.

Let us, then, consider what the mathematician has to say of the actual theorems which comprise the two factor theory. Since 1904, when Spearman published his first statement of it (1), there has been criticism of this step or of that; and several details of the earlier presentations of the theory have had to be abandoned in favour of others having more general applicability. For example, certain *correction formulæ*, and a device known as that of *intercolumnar correlation*, both of which played a part in the earlier statements of the theory, have now been replaced by the more rigorous argument known as the *tetrad-difference* criterion. Criticism, then, has been forthcoming, and has been of great value. The theory has benefited by it, and, we shall maintain here, it stands to-day more firmly than before.

2. CONTRASTED VIEWS

Before we discuss some of the definite criticisms which have been put forward, it is worth while to glance briefly at

a fragrant little blossom which was found hiding coyly among the leaves of the *Mathematical Gazette* (2). In an article entitled *Mathematics at the British Association*, 1933, the following occurs. " The joint discussion on Tuesday was on ' The validity and value of methods of correlation '. The speakers on the paper were Prof. C. Spearman, Dr. W. Brown, Dr. J. Wishart, Dr. S. Dawson, Dr. S. S. Wilks, Dr. J. O. Irwin, and Prof. H. T. H. Piaggio; and Prof. R. A. Fisher was present to indicate tactfully, as he said later in conversation, that the psychologists were being sold a pup." May the present writer " indicate tactfully " that the pup attained mature and healthy doghood several years ago ; and that he is now, after an admittedly difficult adolescence, a fine upstanding creature ? One of the soundest investments psychologists ever made was the purchase of this pup. Spearman, in particular, has trained him with real insight ; and has done more than anyone else to make him a versatile, and, indeed, an indispensable laboratory and class-room companion. If mathematicians have any momentous disclosures to make concerning the animal's pedigree or shortcomings, it would be much more helpful and constructive to publish them than merely to " suggest ", however " tactfully ", that they exist.

In sharp contrast to the above we have Professor E. B. Wilson, who, speaking (1928) of Spearman's summary of the statistical argument which forms the Appendix to the *Abilities of Man*, says, " I have read the proofs with care (including the references to the literature, not all of which has been reproduced in the book), and have found no errors in the mathematics " (3). Piaggio himself has produced " an equivalent but much simpler and more luminous " proof of the two factors theory ; while B. H. Camp has yet another alternative proof, involving N-dimensional geometry, which,

as Piaggio remarks in stating his own simpler theorems, is "a formidable subject even to mathematical specialists". Piaggio continues, "At one time some doubt existed as to the validity of the fundamental mathematical theorems, but the identity (in my opinion) of the conclusions reached by Wilson, Camp, Heywood and myself, using different methods, encourages the hope that these results are now firmly established" (4). Similarly, McDougall has recently said of Spearman's concept of *g*, "This formulation of a general factor in all cognitive operations . . . has been much discussed, and, in spite of much adverse criticism, it has gained increasing acceptance and must now be regarded as a well-established theory." *

3. A CRITICISM WITHDRAWN

But it is still more interesting to turn to Dr. William Brown, one of Spearman's earliest critics, who has reiterated the following (Copenhagen and York, 1932; *British Journal of Psychology*, 1933; *Psychology and Psychotherapy*, 1934). ". . . the tetrad criterion", he says, "escapes criticism of mine which was, as I still contend, rightly directed, in certain cases, towards the 'correction formulæ' which Professor Spearman devised in 1906 and 1910. . . . It also takes the place of the criterion of 'inter-columnar correlation', . . . upon which Professor Spearman previously relied in proving his theory" (5). Continuing his discussion, Brown remarks, "In my own research work with mental tests in 1909, 1910 and 1913, I did not feel justified in considering my results as confirmatory of Professor Spearman's theory. . . . But on the other hand I never contended that my results disproved his theory. . . . My verdict at that date had to be 'Non-

* *Character and Personality*, Dec., 1934; p. 127.

proven ', but certainly not ' Disproved ' " (5). Then follow details of the re-working of the original data of these early experiments, the newer methods being substituted for those Brown suspected. His conclusion is now that the *same* data " do support the existence of a central intellective factor (*g*), and, when taken in relation with the large body of similar evidence accumulated during the last twenty years by Professor Spearman and his students, help to give solid basis to that theory " (6).

4. EARLIER DATA

A somewhat similar instance is worth recording, although, as it dates from before 1904, it cannot be regarded as an instance of criticism of the two factors theory. A great deal of test data had been subjected to statistical analysis ; and the conclusion appeared to be that no general factor of ability was to be detected. These results led Professor E. L. Thorndike, for example, to identity himself with a form of the anarchic, or non-focal, theory of ability * (7). Spearman, however, was able to show that the methods used had failed to take account of the source of error known since then as *attenuation* ; and that, when these same data were re-worked after making allowance for this disturbance, they conformed with the two factor theory just as well as those upon which Spearman himself was then basing it.

5. A SUGGESTED TEST

But to return to newer work. Professor Karl Pearson, the most eminent statistician of the day, and Dr. Margaret Moul, have laid it down that " some 12 to 15 abilities . . . the abilities being settled by psychologists *a priori* to avoid

* Cf. p. 246 *et seq.*

'overlaps', are essential to a satisfactory test [of the two factors theory], the observations to be made on a homogeneous population of several hundreds" (8). When this appeared, Brown, with the assistance of Dr. William Stephenson, set to work to devise and carry out such a crucial test. They even seem to have done rather better. The "homogeneous population of several hundreds", which Pearson demands, was provided by "Three hundred boys [who] were tested in groups of not more than 25 per group. The boys were of age 10 to 10½ years at the time of testing, and were all the boys of that age in the two or three elementary school classes usually accommodating that age. Boys in lower classes, or those who suffered obviously from physical or scholastic disabilities, were not tested" (9). As for the tests themselves, instead of "some 12 to 15", Brown and Stephenson used 19. Their conclusion, though brief, is unequivocal. "The main purpose of our research", they say, "has been achieved, namely to establish Professor Spearman's Theory of Two Factors on an adequate statistical basis" (10).

6. THE COMPLEXITY OF *g*

But criticisms of another type have been, and still are, forthcoming. Roughly speaking they seem to be concerned with the nature of *g*, and to assert its complexity. They will be discussed in a moment; but first it must be pointed out that the probable complexity of *g* is already recognized by the two factors theory. We have said (page 36) that on the physiological side *g* seems to stand in a complex and imperfectly understood relationship to at least some of the contents of the blood stream; and, maybe, to some obscure quality of the brain cells as well. As for the psychological aspect, we have equated *g* (page 183) to eductive power;

that is, to the extent to which a person is capable of educing relations and correlates. Such a definition may be termed functional rather than analytic. It obviously says nothing about the complexity or simplicity of *g*; and to that extent may justly be regarded as incomplete. Thus it is that the two factors theory welcomes the kind of criticism which we are now to consider, as containing in it the germ of future refinements.

(A) *G*, conation and volition. Criticism of this type has come from the pen of Dr. J. C. Maxwell Garnett, who appears to the present writer to suggest that *g* may even involve both conation ("how much the individual *tries*") and volition ("the amount of 'mental energy' he renders available by a *unit 'effort of will'*") (11). Maxwell Garnett adds that this is "only a rough guess and probably a wrong one" (12). Such a suggestion, however, is of obvious value, for it indicates a possible line of research which is bound to add, positively or negatively, to our knowledge. Similarly, McDougall has recently said, "The general factor, *g*, which is revealed and measured in effective mental testing is, I suggest, not merely the quantity of energy available to the individual testee under the conditions of testing; it is rather the *power of the individual to concentrate his available energy effectively upon the task in hand.**

(B) The indeterminacy of *g*. Again, Piaggio also insists on the complexity of *g*, and urges that it cannot be completely 'determined' (13). E. B. Wilson has gone rather further, maintaining that *g* is not only indeterminate, but that its degree of indeterminacy depends on the particular tests of *g* we happen to employ. Thus *g* would somewhat resemble in this respect, or so it seems to the present writer, the so-called *group factors*, which appear or disappear according to the particular batch of tests we are using.

* *Character and Personality*, Dec., 1934; p. 134. (McDougall's italics.)

Spearman, however, while agreeing that such indeterminacy exists, has shown

(1) that it is the measurements of *g* which are in practice indeterminate; *g* itself, the magnitude to be measured, being completely determined; and

(2) that, in any case, the indeterminacy diminishes in practice as one increases the number of sub-tests in the battery or group (14).

In this respect the indeterminacies of Piaggio and Wilson seem to the present writer to be no more than a kind of "sampling" error. It is impossible when estimating *g* in actual practice to measure every activity in which it is involved—although, in theory, this is what should be done. Instead of attempting such an impossible task we sample a few abilities in which *g* is known to preponderate markedly over the *s*. The result will vary somewhat, then, as Wilson (particularly) stresses, according to the "make-up" of our chosen batch of sub-tests. As a matter of fact both Spearman and Dr. J. O. Irwin have gone further than (2) (*supra*), contending that the degree of indeterminacy of *g* is, as it were, controllable; and that by making use of sub-tests in sufficient number we can make it as small as we please (15). It must be added, however, that Piaggio does not agree with this; holding instead that we now require tests with even higher *g*-saturations than those in use at present (16).

It is worth noting in this connection that Professor Godfrey H. Thomson has just made a novel and most interesting suggestion. This is that the indeterminacy of *g* is a function of the *s*'s used to assess it. Thomson says that "if a person has a good outfit of specific abilities" our estimate of his *g* will be "too high. We have mistakenly

thought that he was doing the tests well by the aid of a high *g*, whereas really he had high specific abilities in all or many of them. And *vice versa*, if he is weak in specific abilities " we shall make " our estimate of his *g* too low. We have mistakenly been crediting him with a normal outfit of specifics, whereas really he has been calling heavily on his *g* to gain marks in the tests " (17). This comment is obviously in keeping with Piaggio's demand for tests with higher *g*-saturations ; that is, for tests which stress eduction at the expense of reproduction and, possibly, even at the expense of apprehension. But it must always be remembered that *g* cannot be tested *in vacuo*, it can only manifest itself through an *s* ; and so, presumably, its indeterminacy can never be entirely eliminated. None the less it is true already that, in at any rate one research, assessments of *g* have been made with a degree of determinateness which far surpasses those attained in some important physical investigations. For example, the indeterminacy of *g* in this particular experiment was only in the immediate neighbourhood of 1% ; while that of the fundamental physical magnitude *e*, the electric charge of the electron and proton, amounts to no less than about 30% when measured by the same technical device of " variance " (18).

Let us return, however, to Thomson's suggestion, which seems to be no more than a development of a point noted already on page 30, and which he had previously made elsewhere, speaking of " the probability that of two men with equal scores one may be making it by specific, the other by general, ability " (19). This taken literally is, of course, an obvious overstatement.* No one can make a score by *g* alone, and hardly by *s* alone ; *g* cannot work *in vacuo*. But

* Except, as we have said, in the cases of purely innate or habitual activities in which *g* is not involved. An example of the latter, from the

the underlying idea that, of two people who make identical scores, one may rely on *g* rather than on the *s*, and the other on the *s* rather than on *g*, is certainly acceptable; and has, indeed, already been recognized by the two factors theory. (Cf. page 30 *et sqq.*)

7. A FURTHER POINT OF VIEW

The answer to our first question, *Does the two factor theory "ring true"?* appears then, at any rate from the fundamental statistical point of view, to be, *Yes*. The main steps in the argument are accepted to-day by competent and independent authorities, at least one of whom (Brown) was originally a severe critic; and the theory certainly stands the crucial test of practical application admirably, though we shall have more to say about this last point later.* What of it, then, from the purely psychological point of view? Here the reader can probably form some judgment for himself. It certainly seems to "ring true" to me. I, at any rate, have never met any facts which it fails to assimilate,

writer's own experience, is that of swimming. Learning the "crawl" stroke required a great deal of (conative control of) *g* before the complicated arm, leg and breathing movements were fully coordinated, that is, brought into correct relationship with each other. Even towards the end of the long period of learning, *g* was wholly absorbed by this complex activity; even the momentary intrusion of any other, such as extra control of breathing to cope with water accidentally swallowed, would infallibly produce its complete disintegration Now the movements proceed automatically; and, while still swimming, it is perfectly easy to devote *g* to subtler points of style, such as getting the correct angle of entry for the hands, the right extension of the arms, the right depth of kick, and so on. Thus, whereas my *g* : *s* ratio for swimming was formerly in the neighbourhood of, say, 60 : 40, it is now, say, somewhere about 5 : 95, or even less. It seems not unreasonable to suppose that two swimmers who are equally good at the moment may be making use of ratios as contrasted as these. If so, then the one who has not passed beyond the *g*-stage will, later on, when his *s*'s have been facilitated and have taken over the role of *g*, be much the better swimmer. The man who never learns to swim well is usually the man who never learns to swim without *g*.

* P. 293 *et seq.*

or which could better be assimilated by a monarchic, an anarchic, or an oligarchic theory. As I am not acquainted with any other kind of theory of ability, it therefore " rings true " to me. But, more important for the reader, and, indeed, for myself as well, is the fact that, so far as I can discover, it has not been impugned by anyone else on this score. None the less many further refinements have yet to be made. *G*, *s*, and overlap, seem all to be indisputably established. But *g* and *s* still await complete analysis ; and it is not for the moment to be supposed either that all important cases of overlap have yet been discovered, or even that those which have are so far fully understood.

B : NOËGENESIS

8. A COMMENT ON THE FIRST LAW

Let us turn, then, to the noëgenetic theory. *Does this " ring true "?* The reader will remember the Professor whose, " we don't attach as much importance here ", reaching me from beneath the table, started the present discussion. In due course we adjusted the flex correctly. Then we took turns at making noises into a mouthpiece, and in watching a spot of light trace patterns on a most ingenious revolving paddle wheel. While the Professor was wondering what next he could do with his new playmate, I asked him what criticisms of Spearman's theories he would make. " Well ", he said, " in the first place I don't think that the principle of apprehending experience *is* a noëgenetic one." And then he showed me some green lights in a long tube.

We will begin by splitting up the term *noëgenetic* once again. An experience is " noëgenetic " if it is (*a*) *noëtic*, that is, self-evidently so ; and also (*b*) *generative* of new knowledge. What of the experiences I apprehended when

looking into the Professor's tube? I became aware of a visual experience which (*a*) had those characters I have learnt to call *green-ness*, *vivid-ness*, *there-ness* and *then-ness*; and which (*b*) were also *new* to me. Quite frankly I thought them sufficiently noëgenetic at the time. And yet I believe I know what the Professor really meant—if only because Spearman has, in his *Creative Mind*, said something almost of the same sort himself. Here it is. "When . . . one feels a pain, knows it, and thereby acquires the idea of it, can this idea rightly claim to be something created?

"We may reply that the pain does create the idea in the sense of producing it; and not in the sense of inventing it. Otherwise expressed, the knowledge has no genuine originality, since it does no more than imitate what was already existent. If we entitle it creative at all, we must add that it is so only in the lowest degree" (20).

By way of contrast, Spearman's discussion of the third noëgenetic process from the same point of view may also be quoted. "Is the third principle creative?" he asks, and continues, "On some previous occasion *a* and *b* have been known to possess the relation *r*. Thereafter, by transferring *r* to *a'* which is different from *a*, the mind can evoke *b'*, which is not only different from *b*, but appears to be capable of transcending all existence, known, real or even possible. In short, then, this third principle would seem entitled to be recognized as creative in the *third degree*. And the proposition is here ventured with some confidence that *this degree of creativeness is the utmost to which the human mind can under any conditions possibly attain*" (21).

In another place Spearman says, "There still remains to find a specific name for the manifestations of this first principle as distinguished from the other two" (22). After dismissing as "too venturesome" the idea of calling it the

syneidetic process, he is content to call it the process of *apprehending experience* (23).

It seems, then, that my Professor's first criticism is in itself mild enough. He does not dispute the truth of the first noëgenetic law; he doubts whether it can truthfully be described as *noëgenetic*. If this objection expresses, as I take it to express, a doubt as to whether it can fairly be termed *generative* of *new* cognition, my answer is that it can fairly be so termed; but that the word *generative* must be taken in a slightly different, and less forcible, sense than that which it has when we use it of the third noëgenetic process. Both generate new knowledge; the former merely in the sense of engineering its advent, the latter in the sense of actually creating it. This ambiguity of terminology is, I agree, to be deprecated. But I certainly insist that the Professor's objection is merely a verbal and not a fundamental one. If, however, I have misunderstood him, and he really meant to deny that the process of apprehending experience gives rise to *noëtic* products, then I should meet his objection with a flat contradiction. But I am persuaded that he could not possibly have meant this.

9. A COMMENT ON THE PRESENT OUTLOOK

At the risk of being charged with converting what is claimed to be a text book into an autobiography, I am going to add another reminiscence—even though we have not quite finished with the last. The scene is an International Congress of Psychology. A famous American Behaviourist has just read a paper. Now he and I find ourselves together, recuperating on the steps outside the University. Everyone else seems to be listening to the next paper, and so we exchange a few polite superficialities. He inspects my membership badge. The word "London", beneath my

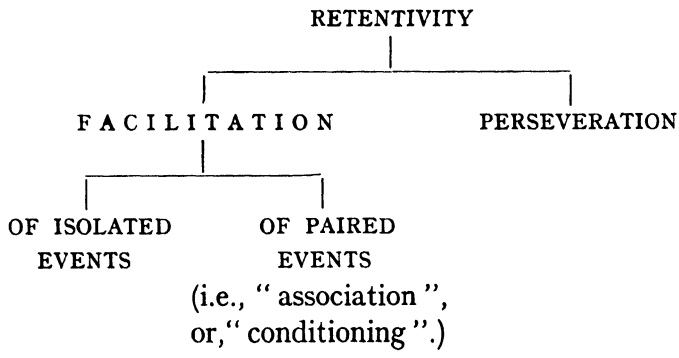
name, acts as a stimulus. " Are you a disciple of Spearman ? " is his vocal reaction. I confess it. Each waits for the other to speak. At length I inquire what he thinks of Spearman's theories. He sighs. " Well, you know ", he says, " I don't seem able to fit them in anywhere. His ideas just don't belong with the sort I get along best with in my work."

This puzzled me greatly for a long time. I knew, of course, that Behaviourists did have ideas ;* but I had not realized that they regarded them as significant, sighing when they could not fit them together, and so on. † It seems to me now that the trouble with my Behaviourist was that he was trying to get a quart into a pint pot ; even, perhaps, trying to coax a large lake into a teaspoon. If one is content to be a Behaviourist, deliberately and explicitly ignoring all phenomena of consciousness, studying no more than the one process of " conditioning ", and believing this to be the single master key which alone can open all the doors of psychological knowledge, then it is hardly surprising if factors, quantitative determinants, and noëgenetic processes fail to " belong ". One's scheme of things is far too small and far too simple for such far-reaching and complex notions to be fitted in. But if, instead, one starts as we have done in these pages, without any prejudice in favour of a particular kind of answer to whatever problems we happen to meet, there is, as we have seen, no difficulty whatever in getting all the relevant ideas, including that of conditioning, fitted together satisfactorily.

* This has been doubted. For example, ". . . the Behaviourist finds no evidence of thought processes within himself ". J. W. N. Sullivan, *Limitations of Science*, p. 169.

† I had always accepted McDowell's " It does not seem likely that the function of consciousness which is common certainly to all higher animals, if not all animals, has any special significance, except in so far as it provides man with an exalted sense of his own importance." *The Mind*, edited R. J. S. McDowell ; Lecture 2, *Physiology*, pp. 72-73, McDowell.

Conditioning has its own little niche as a sub-sub-division of retentivity, thus :



The other quantitative determinants fit in with conditioning well enough ; and the factors and noëgenetic processes in their turn fit in with the quantitative determinants equally well. But this, of course, cannot possibly happen if conditioning looms so large in one's scheme of things that there is no room for anything else whatever. And that seems to me to be precisely where my Behaviourist has gone astray, leading, by the way, most of America with him along the same false trail blazed originally by Pavlov. Changing the metaphor rather abruptly, I would suggest that he suffers not so much from an incapacity to see the wood for the trees, as from such an obsession with one intriguing little shrub that he is inhibited even from admitting the presence, let alone the significance, of the vast surrounding forest.

10. THE RELEVANCE OF RELATIONS

The late Professor Victoria Hazlitt criticized Spearman's views, saying that they ignored " the relevance of the relations educed to the given task. . . . Even such simple and diagrammatic characters as *A* and *B* (Fig. 42) stand to one another in more than one relation, e.g. $A = B$, *B* is to the

right of *A*, *A* is similar to *B* in shape, etc. Which of these relations", she continued, "shall be known when the two are presented?" (24) The answer is, as we have seen (page 148), that in all such cases the particular relations educed will be determined by the quantitative laws. Previous facilitation of one relation may cause that to be educed first; fatigue may even inhibit them all; perseveration of one may inhibit the others; volitional control may play, as we shall see shortly,* an immensely important part in bringing about the eduction of one relation rather than that of another; and so on. Professor Hazlitt's discussion continues, "The essence of intelligence is knowing the relation which serves the purpose in mind. . . . The same holds with regard to the Eduction of Correlates" (25). There seems to the present writer to be no ground at all either for disputing this or for supposing that it in any way conflicts with anything that has been said in these pages.

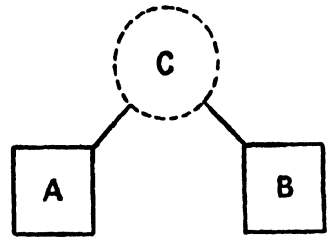


FIG. 42

We can agree with Professor Hazlitt that the really "intelligent" person is the one who educes the relevant rather than the irrelevant relations.† But we can hardly stop there. What is the nature of relevancy? Surely, the very word itself provides the answer to this question. The relevant relation is the one which is itself related; the irrelevant relation is the one with no relations. This needs elucidation. Let us consider an actual problem of a type

* P. 241.

† It is impossible to agree, however, when it is added that Spearman writes "about cognition without bringing in the problem of 'Hormic Control'". The present reader will scarcely need to be referred to chap. 13 (*supra*).

frequently found in " intelligence " tests. The candidate is asked to write down the next two members of the following incomplete series of numbers :

1 2 4 7 11 etc.

Now, between adjacent members of this series, the following relations can, *inter alia*, be educed :

Items		Relations
1 and 2	i	Of the half to the whole.
	ii	Of juxtaposition in the sequence of integers.
	iii	Of differing by 1.
2 and 4	iv	Of a root to its square.
	v	Of the half to the whole.
	vi	Of non-juxtaposition in the sequence of integers.
	vii	Of differing by 2.
4 and 7	viii	Of less-than-half to the whole.
	ix	Of non-juxtaposition in the sequence of integers.
	x	Of differing by 3.

The " intelligent " person, having educed some of these relations between the items, can now pass to educing relations between the relations. Relations iii, vii and x can themselves be grasped as being related ; the next relation in the series being that of *differing by* 4. A relation of identity also holds between i and v ; but not between v and, say, viii ; and therefore affords no further clue. Similarly with relations vi and ix.

Hazlitt's criterion of " intelligence ", namely, that of " knowing the relation which serves the purpose in mind ", can, then, be accepted after analysis. It amounts at rock bottom to educing relations between relations.*

* This is a very important matter which is referred to again in discussing gestalt psychology. P. 249 *et sqq*.

11. A DIGRESSION ON HUMOUR

This topic is worth development in a slightly different direction. Roughly speaking, Hazlitt seems in this place to equate " intelligence " to *seeing the point*; or, rather, to *seeing the right, or the most important, point.* Humour often depends on seeing the wrong, the irrelevant, or the unexpected, point; that is, on the eduction of incongruous relations. This can best be illustrated by referring to a fairly elementary type of humour. Ask a lively first form if they know what a *polygon* is. If they are ignorant of this momentous matter, suggest that they split the word up into syllables; and ask, if they give you sufficient time, whether they know what *poly* means, say, in *Polynesia*, or *polytechnic.* Probably one bright lad at least will get in first with, " Is a polygon a dead parrot, sir? " After all, relations of synonymity between *poly* and *parrot*, and between *gon* and *dead*, are certainly there; though they happen to be quite irrelevant to the meaning of the whole word *polygon.* In short, the relations which have to be educed before *polygon* can be interpreted as *dead parrot* are incongruous from the point of view of the real task of interpreting *polygon* as *many-sided*; and it is in this incongruity that the humour lies.

12. EDUCTION: IMPLICIT AND EXPLICIT

Lastly we must note another aspect of Professor Hazlitt's criticism of Spearman's eductive view of " intelligence " which she developed in the following way: " The essence of intelligence is knowing the relation which serves the purpose in mind, and if there is no purpose in mind, it is unlikely that any relation will be known as the result of presenting two characters. The same holds with regard to the Eduction of Correlates " (26). Two comments seem to be necessary,

though the second will be postponed to §14. As this statement stands, one can hardly take exception to it; but, as it stands, it hardly does justice to Spearman's position. The difficulty lies in the words *knowing* and *known*; which seem to the present writer to indicate that Professor Hazlitt was thinking only of the *ex*plicit eduction of relations and correlates. It is probably true that one would not become aware that two items stood in a specific relationship unless that relationship were relevant to the " purpose in mind ". And, conversely, if no purpose were " in mind ", no relations would be *ex*plicitly educed between items, however multitudinously the latter happened to be presented to cognition. But, purpose or no purpose, items tend in fact always to be grasped in relation to each other; that is, relation-eduction between their characters is almost always at least *im*plicit in our cognitions of them.

Further, even when quite purposeless cognitions occur, items are still cognized in relation to each other. While I am scribbling these lines, " mind wandering " overtakes me; and for some seconds I gaze at the diagram on page 13 of Professor Hazlitt's *Ability* which is lying open on the table beside me, and which has been reproduced here as Fig. 42, page 237. But although my surveyance of this diagram is completely aimless, and indeed, in direct conflict with my present purpose, which is to finish this chapter, yet the lines and dots and letters of which it is composed, are cognized in relation to each other. The diagram is a diagram; and no mere chaos of black marks on white paper. Truly I do not explicitly educe the spacial relations that C is to the north-east of A, and that B is to the south-east of C, as I did explicitly educe the relations that 4 was both the square of 2, and also 2 more than 2. But, since I do grasp the diagram as such, and not merely the isolated elements of it, the

spacial relations which obtain between *A* and *B* and *C* and the rest are *implicit* in my cognition, purposeless though it certainly is. I have indubitably educed them, though not *ex*plicitly.

13. A FURTHER POINT OF VIEW

Once more, before turning to the next topic, we can apply our own tests and ask whether noëgenesis, in particular, "rings true" for us. My own answer can be guessed. I should not have gone to the labour of writing Part 4 of this book, or, indeed, of writing any of it at all, if it did not do so for me. The three processes all seem verifiable within my own experience. This cannot be said of a single one of the others listed in the footnote on page 182; and of no others have I ever heard. But there seem to me to be other equally cogent reasons for holding the theory of noëgenesis to be acceptable. In the first place it seems adequate to account for the entire range of the phenomena of the birth and growth of cognition; and, so far as I know, no other theory even attempts this. Secondly, I have met no criticisms of it, other than those which have already been, or are shortly to be, discussed in these pages; and, as the reader has I trust gathered, I am not persuaded that anyone of these is fatal.

C: THE QUANTITATIVE DETERMINANTS

14. EDUCTION AND VOLITION

Discussion of the quantitative determinants may be best begun by reference back to Professor Hazlitt's emphasis on the role of purpose in "intelligent" activity. Its special value is that it reminds us of the part played in cognition by volition and by the mental sets which are volitionally engendered. Aveling has treated this matter experimentally,

suddenly presenting a complex visual stimulus to his subjects (27). Sometimes they merely observed the stimulus in the ordinary way. But at other times they made first, before the stimulus was to be presented, a resolution to note a particular item or a particular relation should it happen to occur during the subsequent experience.

In this second type of experiment, then, an unconscious mental set towards cognition of a certain type was volitionally induced (cf. chap. 13, *supra*) ; and Aveling found that this greatly enhanced the likelihood of detecting the particular item or relation.

On the whole these observations confirm Professor Hazlitt's contention. One's purpose does, very definitely, modify one's cognitions. But the expression " purpose in mind " is rather loose. The purpose may in a very real sense, be quite " out of mind "; that is, we tend to be actually unconscious of it at the time it does its work. We accept a task by an appropriate act of will ; and the purpose of our subsequent activity is thereby fixed. But the mental set which the volition sets up functions unconsciously.

This discussion can best be brought to a close by warning the reader that the two following paragraphs contain twelve typographical errors ; and by inviting him to see how many he can detect while reading as nearly as possible at his normal rate. All that is required is the resolution to let nothing escape ; and more errors should then be detected than happened when, in chapter 8, the experiment was performed without volitional direction.

15. CONSTANT OUTPUT QUESTIONED

Let us return, for the last time, to the Profesor who *didn't attach as much importance.* While I was looking thruogh the same tube at another of his green lights, he was good enough

to dilate still further. " As for Spearman's law of constant cognitive outpnt ", he said, " I don't believe cognitive output *is* constant in quantity." The obvious method of dealing with this *non credo* is to point out that Spearnan expressly shares it. He has never claimed that outqut is constant; in actual fact he claims just the reverse. The law my Professor was criticisng states that output *tends* to be quantitatively constant (page 67). But this law is supplemented by annother, that of variability or oscillation, which says that this tendency is never realised for very long at a time (page 91).

16. AN IMPORTANT CAVEAT

It would be unfair to Spearman, howsver, to close these remarks witkout noticing the following quotation from his own writings.

In introducing his own discussion of the quantative determinants, Spearman contrasts them with the neögenetic processes, which he refers to in this place as thos which account for the *quality* of cognition. " It must be frankly conceded ", he says, " that as regards these further principles [i.e., the quantitative ones] our present information is still far from complete. Whereas the three [laws] of quality appear to be fixed irrevocably (except, of course, for corrections in detail), the following of quantity offer a good prospect of being eventually amended in a radical manner " (28).

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CHAPTER TWENTY-SEVEN

OTHER THEORIES

1. Different "Schools" in Current Psychology.
2. Introspective or Existential Psychology.
3. Behaviourism.
4. Psychoanalysis and Related Schools.
5. Purposivism or Hormic Psychology.
6. Gestalt Psychology.
   (*A*) The concept of the "gestalt".
   (*B*) The concept of "insight".
7. Other Theories postulating Factors.
   (*A*) Professor E. L. Thorndike.
   (*B*) Professor Godfrey H. Thomson.
   (*C*) Professor Truman L. Kelley.

Two problems now remain. (1) Do these factor and noëgenetic theories, and the quantitative determinants, get us anywhere worth while? (2) Are there no better alternative theories? It is proposed to deal here with the second of these two problems; and to discuss the other in the last chapter of all.

1. DIFFERENT "SCHOOLS" IN CURRENT PSYCHOLOGY

Psychological theories are many. They have recently been classified, both by Professor R. S. Woodworth in his *Contemporary Schools of Psychology*, and also in the much more formidable *Psychologies of* ~~1930~~, edited by Professor Carl Murchison. Here we will adopt Woodworth's grouping. In the work already mentioned he devotes one chapter to each of the following:

Introspective or existential psychology.
Behaviourism.
Gestalt psychology.
Psycho analysis and related schools.
Purposivism or hormic psychology.

First, we had better inquire to which of these schools Spearman adheres. Woodworth's answer, which is the correct one, is *none* (1). Spearman himself sub-titles his own summary of his position, *A School to end Schools* (2); and Woodworth's only detailed reference to him occurs in the last chapter of all, entitled, *The Middle of the Road* (3). It is as follows:

"A FEW FOREIGN PSYCHOLOGISTS OUTSIDE THE SCHOOLS

"In Great Britain, as compared with the United States or with Germany, the number of professional psychologists is small, but their standard is high. Professor Carl Spearman of the University of London (born 1863) might be cited as the head of a school, but it would be a different type of school from those we have described. Americans are familiar with the long-continued debate between him and Thorndike on the nature of intelligence, Thorndike supporting the view that intelligence is an aggregate of numerous special abilities that are unrelated to one another except as each depends on facility of learning, and Spearman, while recognizing a special ability for each type of performance, insisting also on a general ability which enters in some degree into every variety of intelligent behaviour. This general factor he designates as "*g*", and the debate over *g* has gone on actively for twenty-five years. Spearman has recently reached the conclusion that this general factor consists very largely in the ability to see and use relationships. Though both Spearman and Thorndike have had many pupils and fellow-workers, I do not include them among the schools, because the issue between them is in a fair way to be settled by evidence. Their controversy, then, is one of the standard scientific type, rather than a debate

between rival schools. The issue between two such schools as the behaviouristic and existential cannot be settled by evidence but is a matter rather of preference."

Now we can turn to Woodworth's list of schools, and see how many of them offer alternative explanations of the facts we have encountered.

2. INTROSPECTIVE OR EXISTENTIAL PSYCHOLOGY

" Existential psychology at the present time ", Woodworth says, " is rather an ideal or a programme for investigation, than anything like a rounded body of knowledge " (4). With this the present writer would hardly agree. It is true that introspective or existential psychology has no *alternative* to offer either to noëgenesis or to the quantitative determinants ; and as for the factors, they stand for ever beyond the reach of introspective investigation, so that existential psychology can have nothing whatever to say about them. But Woodworth has omitted to mention that noëgenesis owes everything, and the quantitative determinants much, to the introspective method ; and that in this important sense introspective psychology, having given rise to them, *is* a " rounded body of knowledge ".

3. BEHAVIOURISM

Sufficient has been said already (chap. 26) to show that behaviourism, far from offering any alternative to the theories we have discussed, deals merely with one small and isolated topic which it studies to the exclusion of all others. By denying the existence of any process other than the allegedly physiological one of conditioning, it effectively shuts its eyes to all problems of psychology whatever ; and, naturally enough, does not even admit the necessity of

proffering a substitute for noëgenesis, the factors and the quantitative determinants.*

4. PSYCHOANALYSIS AND RELATED SCHOOLS

Here we are dealing with schools whose primary concern is not with the psychology of cognition, but with that of orexis. Thus it is hardly to be expected that they will offer any alternative to our cognitive theories. None the less they are eminently worth considering here. Behaviourism is swallowed whole by the theories enunciated in these pages; but psychoanalysis, on the other hand, supplements them in a way the significance of which it would be difficult to overestimate. By far the most important point of contact is to be found in the law of control (chap. 13). The psychoanalyst's researches and conclusions are of immense moment to us in so far as they are concerned with the orectic phenomena which promote failure of conative or volitional control, or of both.

5. PURPOSIVISM OR HORMIC PSYCHOLOGY

Once more we have a psychology concerned less with cognition than with orexis. Professor William McDougall, in particular, offers a detailed and masterly analysis of the innate propensities which, at rock bottom, dictate the ends to which conative and volitional control shall direct *g*. Hormic psychology, like psychoanalysis, supplements our theories in a most important fashion; the point of contact being, again, that of control.

* I should like to thank Professor Spearman both for the following comment and for permission to reproduce it here:

"Some people will think that your treatment of Behaviourism is too drastic. At most, the view as you depict it is that of Watson. Actually, Behaviourism has been watered down until it means little more than special emphasis being laid on external behaviour; and such emphasis is in many circumstances, I believe, of great value. *Of course, however, one can make the criticism that such a diluted doctrine forfeits any claim to be credited with startling originality.*" (Present writer's italics.)

6. GESTALT PSYCHOLOGY

We turn now to a school which does offer an alternative to noëgenesis, though not at all to the factors, and hardly to the quantitative determinants. Adequate examination of its tenets would occupy many more pages than can be spared here; and comment will therefore have to be limited. All that will be attempted is a discussion of two of the main findings of this school; showing, in the opinion of the present writer, that they are readily explicable in the terms we have employed; and hence that they cannot be regarded as fundamental principles, which is what their proponents maintain.

(A) The concept of the "gestalt". It is held by this school that cognition is never cognition of a single item, but always that of items forming a unitary "configuration" or "gestalt". In so far as this is true it seems primarily due to confluence, that is, to relation eduction (cf. page 146 *et sqq.*). For example, each diagram in Fig. 15 (page 149) tends to be cognized as a single unit—that is, as a gestalt—rather than as a pair of items; but the gestalts are such only because, in each instance, a spacial relation has been educed between the circle and the line. That the gestalts, unities, or configurations, differ one from another is due solely to the variety of the spacial relations which bind the items together; for the latter are the same throughout the whole series of diagrams. Each circle is grasped in a particular and unique relation to a line, and vice versa; and it is thus that the two come, in each diagram, to flow together in a unique way, and to be bound into a gestalt which differs from every other gestalt.

Another example is, as we have seen, provided by the Müller-Lyer diagram (Fig. 19) which really stupid people are

incapable of grasping as a gestalt. Consequently they do not fall victims to its illusion. It requires a certain minimum amount of *g* to educe the spacial relations which certainly subsist between the horizontal and oblique lines; and, unless these relations are educed, confluence will not occur, the diagram cannot form a gestalt, and the horizontal lines can be compared without interference from the "spaces".

As for Fig. 16 (page 152), this illustrates still further the fact that the cognitions of people of normal "intelligence" are not necessarily cognitions of gestalts. It is quite possible to survey the black lines for some considerable time without their forming a gestalt. They only become one when they are grasped in relation to each other.

Thus it is not denied here that the normal tendency is to grasp things as cognitive unities. But it *is* maintained that such gestalts are not the fundamental units of cognition. The fundamental units of cognition are apprehended experiences, educed relations, and educed correlates. These, when bound together by inter-relationships—which, more often than not, is what does happen to them—become confluent and are cognized as gestalts.

(B) The concept of "insight". The gestalt school maintains that the basic unit-process of cognitive growth is insight into a situation grasped as a whole; that is, insight into a gestalt. But insight appears to be but another name for Professor Hazlitt's "grasping the relevant relations"; and that has been discussed sufficiently already (page 236 *et sqq.*). The present writer considers insight to be a very useful conception. We can regard a person as "intelligent" in so far as he shows insight into complex situations. But such a concept is obviously extremely crude, and demands detailed analysis. Of this it has already had sufficient. On the strength of the previous discussion the following equation is

offered : " Insight " *equals* Hazlitt's " knowing the relation which serves the purpose in mind " ; and the ultimate mechanism of this is eduction—frequently that of relations between relations.

7. OTHER THEORIES POSTULATING " FACTORS "

(A) Professor E. L. Thorndike. It has already been hinted that some psychologists hold that the two factors theory is not the only possible interpretation of the results which appear when data obtained by testing cognitive activities are subjected to statistical treatment. For example, we saw (page 246) that an anarchic, or non-focal, view seems still to be favoured by Thorndike. But this writer also suggests that " there is a general rough correspondence or correlation such that a man notably intelligent in one respect will usually be above the average in others also " (5), thus appearing to accept some sort of monarchic or uni-focal view as well. Further, Thorndike says that " for ordinary practical purposes, however, it suffices to test for three ' intelligences ' which we may call mechanical intelligence, social intelligence and abstract intelligence " (6), which savours not a little of a faculty, oligarchic, or multifocal view. All this seems a little too chameleonic for full discussion ; and we shall here be content with the following comments. First, Thorndike's anarchy of " unrelated special abilities ", which he equates to neural " conduction units " (7), does not seem to be incompatible with the (also neural) *s*'s of the two factors theory. Secondly, the correlation which Thorndike admits with such apparent reluctance would seem clearly to be explicable as due to *g*. Thirdly, the two factors theory already recognizes the existence of mechanical, verbal, and logical overlap which, together with *g* and such an orectic factor as that of preference, may well account for Thorn-

dike's three " intelligences ". Finally; speaking at a Conference on Examinations in 1931, Thorndike said, " Abstract intellectual ability with verbal content does show substantial unity, so that we can, by a suitable battery of tests, approximate a measure of it uncontaminated by other factors—of all of it and nothing but it " ; which seems to the present writer to sound remarkably like a belated conversion to our own standpoint.

(B) Professor Godfrey H. Thomson. In addition, there is the " sampling " theory sponsored by Thomson, to whom reference has been made already (page 229). But, as Thomson himself says, and as Piaggio, for example, has also shown, the sampling theory becomes in practice the two factors theory, except when overlap exists (8). Thomson seems to hold that cases of overlap vitiate the two factors theory, and make it necessary to postulate a theory of group factors, such as he claims the sampling theory to be; but it is only fair to point out that he himself has failed to isolate and name a single one. (This, indeed, is hardly surprising, since he seems to regard his " group factors " in one place as neurones (9), and in another place as " some inherited genes for this or for that, some points of training or of experience during education and during life " (10). In either case their number must surely run into millions; and the suspicion is inevitable that, after all, they are really " specific " and *not* " group " factors.*) The only " group ", or " broad ", factors known to-day are, with one exception to be noted

* It may be added that, in contrast to the above, Thomson postulated in one of his investigations (with dice) thirteen, and in two others thirty-six, group factors. Spearman comments, " In truth, there does not exist any *the* sampling theory, but only an indefinite number of sampling theories, each requiring discussion separately." (BJEdP, June 1931. Spearman's italics.) It may be further added that the sampling theory was originally mooted by Spearman himself, only to be rejected as incompatible with the facts.

in a moment, those which have been discovered by two-factorists; those, that is, which have been discussed already (page 42 *et sqq.*) under the title of "overlap". Further, Brown has made use of his joint research with Stephenson (page 227) to make a comparison between the ways in which the two factors and sampling theories fit the facts discovered in that research. The outcome of this particular experiment, which, it will be remembered, was devised solely to meet Pearson and Moul's requirements for a crucial test of the two factors theory, is shown in Fig. 45 (page 294). It is entirely favourable to the two factors theory.

(C) Professor Truman L. Kelley. Discussion of group factors leads naturally to the work of Kelley, who also stresses their importance, and has, in the main, corroborated the findings we have enumerated in these pages. Kelley's disagreements with Spearman are, the former says, "in the importance and extent of a verbal factor and in that of a mental speed factor" (11). Kelley agrees about the *s*'s, saying "that a large number of specific motor (probably also sensory) factors exist" (11). Lastly, he also finds evidence of a general factor, but he interprets it, he says, in a different way from that which Spearman adopts. According to Kelley, *g* involves maturity, race, sex, and "differences of antecedent nurture" (12). Again, this does not seem incompatible with what has been said in these pages. Kelley's approach to *g* has been analytic; our own has been functional. *G* has been regarded here merely as eductive power (page 183), and as resembling an undifferentiated cognitive energy (pages 54 and 116); and we have all along held its manifestations to be "associated with certain basic conditions" (page 102) such as those of age, heredity, health and sex. As for Kelley's speed factor, the reader familiar with Spearman's discussion of the evidence for this (13), will

probably be as surprised as the present writer if this, too, does not prove on further investigation to be but a function of *g*. We may best conclude, perhaps, with Kelley's own remark, namely, that his findings and Spearman's are " quite remarkably in harmony " (14).

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CHAPTER TWENTY-EIGHT

THE SIGNIFICANCE OF THE PRESENT THEORIES

1. Introduction.

A: THE THEORETICAL POINT OF VIEW

2. Limits of the Problem.
3. The Divorce between Practice and Theory.
4. Fundamental Principles in other Sciences.
5. The Relative Sterility of Psychology.
6. The New Outlook.

B: THE PRACTICAL POINT OF VIEW

7. Problems of Vocational Choice.
8. Problems of Road Safety.
9. Problems of Political Representation.
   (*A*) Introduction and caveat.
   (*B*) The problem.
   (*C*) Present guarantees of political fitness.
   (*D*) Suggested guarantees.
   (*E*) Conclusion.
10. Problems of Universal Suffrage.
11. Problems of the Popular Press.
12. Problems of Talent and Reward.

1. INTRODUCTION

Now the last question must be faced. Do our theories get us anywhere worth while? It is a question of obvious importance; and, further, it is a large one which would be interpreted by different people in different ways. The philosopher, interested in the nature of mind or in the synthesis of human knowledge, would hardly be satisfied with the answer which would content the schoolmaster absorbed in the problems of his class room; and neither would necessarily be impressed with the evaluation made by a profes-

sional psychologist as such. It comes, then, to this. Whether you regard noëgenesis, the factors, and the quantitative determinants as leading anywhere worth while or not, must depend very largely on where you may happen to want to go yourself; that is, on your own interests and outlook. For example, the person whose estimate of the value of a scientific theory is governed by the extent to which he can use his own interpretation of it as ammunition in religious apologetics will not easily be persuaded to rate these theories highly.*

A moment's reflection will make obvious the impossibility of answering the present question from every conceivable point of view; and, in fact, only two representative ones will be chosen here. First, we shall take the view legitimate in the professed psychologist, who is entitled to expect us to explain what these theories do for psychology itself. How much better off, he might ask, is psychology after Spearman's thirty years of research? This may for brevity be called the *theoretical* point of view. And the other view we shall discuss is that of the layman interested in any insight which psychology can give him into his own mentality or into that of the society of which membership is forced upon him. This may be termed the *practical* point of view.

A: THE THEORETICAL POINT OF VIEW

2. LIMITS OF THE PROBLEM

A beginner in psychological studies once made the following comment to me: "I can't help thinking", he said, "that Professor Spearman's outlook is too completely intellectualistic." It would be easy to scoff at the obvious way in which this remark misses an essential point in Spear-

* The question of whether *g* survives the basic condition of death has already been raised in the present writer's hearing.

man's teaching. As a comment on the latter it is almost as fatuous as would be the reproach that Einstein is excessively mathematical in *his* outlook. But it does nevertheless serve two important purposes for us. In the first place it reminds us of certain limitations inherent in these theories; and, in the second place, it helps us to narrow down the scope of our present problem.

First, then, we are dealing primarily with a psychology of cognition, and not of orexis; with a psychology of talent, and not of temperament; with a psychology of ability, knowledge and intellect, and not of instinct, emotion and volition. I find in Spearman's teaching sufficient to account for the fact that I, personally, can neither play a musical instrument nor rely on being able to identify a musical theme, or even whistle it in tune; although I may be quite familiar with it. But there is almost nothing in the same teaching to account for the even more important fact that, in music, though Delius attracts and enchants me, Mozart merely bores or actually irritates. While *The Walk to the Paradise Garden* has all the significance of an exquisite painting, *Eine Kleine Nachtmusik* seems as vacuous as the sort of design which used to be found careering up the staircase wallpaper in many a middle-class Edwardian home.

The scope of our present problem is, then, considerably narrowed. Our hypothetical psychologist will have to be content to inquire what Spearman has done, not so much for psychology, as for the psychology of cognition. My own answer would be quite definite; he has, I hold, accomplished the task which his researches into the nature of "intelligence" drove him to attempt, and has left order where before was only chaos.

3. THE DIVORCE BETWEEN PRACTICE AND THEORY

We saw in Chapter 3 that the term "intelligence" has almost an infinitude of meanings. But we did not stay then to note another fact about it, namely, that in text-books of psychological theory it has scarcely ever been thought worthy of discussion at all. To Ballard's oft-quoted dictum, "While the teacher tried to cultivate intelligence, and the psychologist tried to measure intelligence, nobody seemed to know precisely what intelligence is" (1), we might well add that the writers of theoretical text-books appeared never even to have heard of it. Though "intelligence" was *mana* to the experimentalist, a term with which great magic could be wrought in practice, yet to the theorist it seems to have been completely *tabu*. What prospects, we may ask, could psychology have, practice and theory being thus severed?

4. FUNDAMENTAL PRINCIPLES IN OTHER SCIENCES

Millenia ago the observations of the astrologer and of the calendar maker formed a foundation upon which astronomers have since piled a myriad facts hidden from their predecessors; and to-day this labour is rewarded as it deserves. Whether he uses Newton's laws of motion, or Einstein's refinements of them, the modern astronomer has at least a body of fundamental theoretical principles to guide him in his investigations. Centuries ago the alchemist dissolved, calcined and fused his elements; and in due time the chemist usurped his role of investigator, and enormously enlarged its scope. Their lineal descendant to-day can turn for guidance in his laboratory to a body of theoretical principles which is the outcome of their discoveries. The geneticist takes the experiences of farmer and breeder,

supplements them with his own more subtle experimentation, and, piecing the fragments together, discerns the basic pattern to which all alike conform. Such concepts as those of gene, and chromosome, and Mendelian unit, revitalize his practice when, theorizing over for the while, he resumes it once again. And a time comes when botanist, zoölogist and even geologist lay aside the microscope, and, having thought upon the significance of what it has shown them, return to their studies armed more potently than before with the theory of evolution.

5. THE RELATIVE STERILITY OF PSYCHOLOGY

It would almost seem that psychology were the only soil in which the seeds of observation—casual, experimental, or both—have never in the past taken root, to yield, sooner or later, a harvest of valuable theoretical principles or laws. Those principles which have from time to time been put forward have been principles *ad hoc*. A few have dealt with memory, some with attention, some with the acquisition of skill, and so on. But not one of them has ever been applicable universally, or even throughout a field of notable extent. No one has ever enunciated a principle which dealt, he was prepared to maintain, not only with the phenomena of memory, but also with those of attention; and not only with those of attention, but with those of "intelligence", and skill, and learning, and language, too. James could fitly describe the psychology of his day as, "A string of raw facts; a little gossip and wrangle about opinions; a little classification and generalization on the merely descriptive level; a strong prejudice that we *have* states of mind, and that our brain conditions them; but not a single law in the sense in which physics shows us laws, not a single proposition from which any consequences can causally be deduced. We

don't even know the terms between which the elementary laws would obtain if we had them. This is no science, it is only the hope of a science" (2).

6. THE NEW OUTLOOK

Our present claim is a vast one. It is that Spearman has closed the gap between practice and theory; and in doing so has raised one important branch of psychology from being merely "the hope of a science" to being as truly scientific even as physics. Experimental investigation in laboratory and classroom, supplemented where possible by mathematical analysis, have at last disclosed not only "the terms between which the elementary laws" of cognition obtain, but even the elementary laws themselves. And James was right. In his day the very terms, except in one instance, were unknown. The fundamental *factors*, and processes of *eduction*, had never even been guessed at; only the *apprehension* of experience had then been heard of. But now the position is very different. *The psychologist of to-day stands on the same footing as astronomer, physicist and chemist. He also has a body of unequivocal, fundamental and universal principles to guide his practice within the vast realm of cognition, and to illuminate his findings there.*

B: THE PRACTICAL POINT OF VIEW

We turn now to the second and practical point of view. There seems much in the factor theory and in the quantitative determinants to interest a layman and to strike him as important enough to be worth his thought; even if noëgenesis may seem rather academic. Any study which deals with differences in talent between one man and his neighbour, and within the same man on different occasions, is obviously of far-reaching practical importance. Let us begin by relat-

ing the ideas of *g* and *s* to the problem of choosing one's occupation. Here we have definite facts to deal with, for the National Institute of Industrial Psychology has not only developed a technique of vocational guidance along these lines, but has also been able to demonstrate its practical value.

7. PROBLEMS OF VOCATIONAL CHOICE (3)

Occupational misfits may be divided very roughly into three classes. First, we have the square pegs in round holes; as when the "born" musician finds himself on the office stool, faced with tasks for which he has no talent. Secondly, there are the big pegs in the small holes, and the small pegs in big ones. Examples would be, respectively, those of an able legislator condemned to secretarial work in a local branch of his trade union through being unable to secure election to Parliament, and of the hopeless back-bencher who secures election at the other's expense. Thirdly, there are such temperamental misfits as that of the shy and diffident man who is forced to attempt door-to-door salesmanship. Any two, or all three, types of occupational maladjustment may, of course, and all too frequently do, co-exist.

It must be obvious that misfits of the first of these kinds are due to a lack of correspondence between the *s*'s required by the occupation and those possessed by the worker. In the second example, the disharmony is due to *g*; the worker possesses either too much or too little for his work. In the third, or temperamental, type, the maladjustment is fundamentally an orectic one; and its discussion, consequently, does not lie within the scope of this book.

The occupational psychologist's basic task in formulating individual guidance is the assessment of the amount of *g* his

client possesses, so that he can advise as to what may be termed the latter's vocational *level*. He must know whether to recommend, on the one hand, such an elaborate course of training as that required for the profession of, say, solicitor or engineer; or whether to recommend, on the other hand, only preparation of the type which is likely to lead no further than to clerical or manual posts entailing but a small degree of responsibility or initiative. When this basic assessment of *g* has been made the vocational expert then tests for a few *s*'s of crucial importance, in order to determine his client's vocational *type*. The N.I.I.P. employs, in particular, carefully devised tests of clerical, mechanical, and linguistic ability. These are used as a matter of routine; but when necessary other *s*'s are measured as well, either by tests, or by reference to information which has been collected from the testee and from those who are intimately connected with him.*

On published evidence the N.I.I.P. claims up to 79% success in work of this description; but its standards are high; and on the evidence the claim seems to me not only reasonable but modest. To-day such work is spreading. Some of the more advanced and enlightened Education Authorities are adapting the Institute's technique with the aim of providing boys and girls when they leave school with something more accurate than the usual written testimonial, and more useful than the usual oral beatitude. The importance of such work is surely self-evident. An incalculable amount of social and personal discontent could be avoided by an extension of this particular branch of applied psychology.

* Temperamental peculiarities are also considered, as we have said already; together with the testee's financial resources; the necessity, perhaps, for his beginning work quickly; his education; any unusual vocational opportunities he may have; and a host of other details, the importance of which in most cases is negligible, though in any particular case it may be overwhelming.

8. PROBLEMS OF ROAD SAFETY

Let us turn now from vocational to an example of what might be called avocational psychology. A great many people to-day drive motor cars ; and the results, in terms of corpses and maimings, are familiar. The role of *g* and *s* in car driving is too obvious to require very lengthy discussion ; but in passing we may just remark that the N.I.I.P. has recently developed a series of eleven tests for motor drivers (4). Six of these are primarily tests of *s*'s, some of which probably " overlap "; four are tests of orectic traits ; while the last is a test of " road behaviour and manipulative ability ", which seems to involve not only *s*'s and orexis, but a great deal of *g* as well. But it is noteworthy that *g* is not tested as such ; for although it is certainly essential for the acquisition of the skilled movements driving demands, it should not be required for their actual performance after they have once been mastered. (Cf. page 72.)

An extremely important point arises, however, concerning the extent to which *g* may be necessary in order that the acquired habits may be brought into action at the right rather than at the wrong moments. For example, a good deal of risky " cutting " into, and out of, traffic streams, and of dangerous cornering and braking, seems to me to be due to the faulty eduction of spacial and temporal relations. The driver " thinks " he has room and time to do so-and-so, and the correct muscular habits are performed perfectly. But if his eductions are at fault, his *s*'s may well be of no avail to compensate for his inadequate *g* ; and disaster may follow.

But it is more interesting here to examine the role of the quantitative determinants, and to ask how these may contribute to accidents on the road. Fatigue and oscillation are so obviously important that they should require no more

than the mentioning; and yet the folly and danger of driving a fully-laden car for hour after hour on strange roads crowded with other holiday-makers seems never to occur to many people accustomed chiefly to driving an almost empty car for short spells on familiar roads. But from my own experience I should regard the phenomenon of constant cognitive output as perhaps the most significant from the present point of view. Quite recently, while threading my way across a large, busy and complicated, but not unfamiliar road-junction, a cyclist saved himself from immolation beneath my wheels only by his own skill. I had noticed a lorry approaching hectically from my right, and was far too occupied with the urgent problems it presented to see or hear the cyclist who pounced upon me from the other side. Again, most motorists have at some time or another had my experience of driving for minutes on an otherwise open road behind a slowly-moving car which lurched and staggered from side to side, while the driver, oblivious to hootings from behind, admired either the scenery or his companion in the front seat. Truly, this is inconsiderate rather than dangerous in itself; but it does lead to bad temper; and bad temper tends to inhibit sound eduction. The parts which the other quantitative determinants, for example, facilitation, perseveration, and basic condition, may play in accident causation, can be thought out by the reader himself.

9. PROBLEMS OF POLITICAL REPRESENTATION

(A) Introduction and caveat. The relevance of what has been said about *g* and *s* to political and legislative life is extremely interesting and important. But a very real difficulty arises at once. The moment one begins to apply psychological principles in such a practical field as that of politics, there is an irresistible tendency to cease being

merely a psychologist; and consequently the certainty of exceeding the true scope of such a book as this is primarily supposed to be.* The following, then, must be taken as expressing no more than my own present personal views on the matters discussed.† As such, they chiefly concern myself and the ladies and gentlemen who solicit my votes at election times. The only justification, but I think it an adequate one, for setting forth such views in such a place is that I can thereby drive home still further the crucial fact that the theoretical principles we have discussed do have natural and important applications in practical life, as well as in the psychologist's laboratory. It is obviously the reader's own task to make his own applications of the same principles to those particular aspects of life which interest him most. If he selects the fields which I have selected, and if the results he obtains differ from those which I obtain, that in no way invalidates the principles themselves. It does no more than illustrate the complexity of the issues involved; and hints, I think, at the urgent necessity for making such attempts frankly, in order that well-grounded views may emerge, to form eventually a basis for fruitful, planned activity.

(B) The problem. With so much apology, then, I submit

* There seems little danger in this if we distinguish between the different *moods* of the various parts of the following discussion. At first we adopt the *indicative* mood, and say, "Legislation requires talent, that is, *g* and the appropriate *s*'s." Next, in the *optative* mood, we sigh, "O! that our legislators were those who are most talented for legislation!" Thirdly, adopting the *imperative* mood, we cry, "Let us have those legislators who are the most talented for their vocation!" And, lastly, in the *interrogative* mood, we ask, "How may the talent of our legislators be most certainly assured?" It is only the first, the indicative mood, which is the mood of the psychologist as such; the others, which are those of the reformer, should be distinguished from it. (Cf. P. Sargant Florence, *The Statistical Method in Economics and Political Science*, chap. 1, where this concept of mood is discussed with great clarity and cogency.)

† For example, it must certainly not be supposed for a moment that Spearman would identify himself with any of the *opinions* expressed in this paragraph or in §§ 10 and 11.

that a major political problem to-day is the selection of the most suitable people for the most important legislative posts; and, assuming without discussion that Membership of the House of Commons should be tantamount to occupying an important legislative post, I propose to examine how far the present methods of election to that body seem to me to fall short of what the principles we have developed here suggest as likely to select the most suitable people.

I take it that, in general terms, we are seeking representation by persons with adequate *g*, and with the appropriate *s*'s sufficiently well developed. Such an assumption ignores the orectic aspects which it has been the tradition in England to regard as more important than the cognitive ones. But this tradition, that a clean heart has in itself more practical value in the long run than a clear head, that the amateur (never, be it noted, the professional) trained in sport is always to be preferred to anybody trained merely in thought, is such transparent nonsense, and has led to such political sterility, that it may in time lose ground even in the only country in which it ever received more than the contempt it obviously deserves. But, in any event, orexis lies outside the scope of the present work; and we shall ask, then, how far present electoral methods tend to secure legislation by people of outstanding " intelligence " and specific ability for their vocation.

(C) Present guarantees of political fitness. At the present time most of the potential voters in a constituency can expect to have no more than the following guarantees concerning the *g* and legislative *s*'s of any candidate who has never actually occupied a seat in the Commons on some previous occasion. In the case of former Members voters who are sufficiently interested may sometimes get a little guidance from past volumes of *Hansard*. The present guar-

antees of an untried candidate's political capacity are that he is neither (*a*) an ordained minister of the Established Church, nor (*b*) a Peer of the Realm ; that he is neither (*c*) an *undischarged* bankrupt, nor (*d*) a *certified* lunatic ; (*e*) that a few people (concerning whose motives, integrity and capacity the voter may or may not have some reliable or unreliable information) have, for reasons sufficient to themselves, seen fit to "nominate" him ; and (*f*) that some person, not necessarily himself, or some organization of persons, is prepared to wager £150 to nothing that he has at least one chance in eight of getting any particular vote cast in the constituency.

Now most of this seems to me to be quite noticeably irrelevant. Few people, probably, would maintain that either blue blood or even subscription to the Thirty-Nine Articles actually *proves* political incapacity ; indeed, conspicuously able legislators have come from both Peerage and Clergy perhaps as frequently as from most other walks of life. There is, superficially, rather more to be said in favour of the lunacy bar ; but it is certainly arguable that the standard of certification needs revision. (In any case, while certification remains the function of the medical profession it is surprising that downright errors are so relatively infrequent.) And, regarding bankruptcy, I should like to add that, at one General Election at which it was my duty but doubtful privilege to vote, I found myself forced to do so in favour of a racing tipster and writer of detective fiction who, after being heavily defeated at the poll, went abroad to engage in the film industry, and died very shortly afterwards in a state of insolvency which his election would probably neither have averted nor disclosed.*

* It is only fair to add that, since this gentleman's death, the estate has become entirely solvent.

(D) Suggested guarantees. I am going to suggest, then, that no person should be eligible for nomination to a Parliamentary seat until he had obtained very high marks at a written, and possibly oral, test in modern world history, in the social and political history of his own country and of its imperial accretions, in political theory, in descriptive economics, and even in a little social psychology. In addition, he should be interested in several specific topics such as international relations, health, education, housing, trade, transport, and so on; and should pass handsomely a thorough test of his factual knowledge of a limited number of them. His knowledge having been proven, he could be allowed to vote in the House just as often as his chosen topics happened to be under discussion. Then he might be able to make positive contributions of some value to the debates, and come to wise decisions on the issues involved.

So much for the theoretical side. As for the practical side, it seems self-evident to me that no one should be allowed to interfere in national affairs until he had served a considerable and unimpeachable apprenticeship in local governmental legislation; and equally obvious that, not until he has had long and flawless experience in the conduct of national affairs should he be allowed to meddle in international ones.

All this would at least ensure that persons elected were possessed of the requisite *s*'s. But what of *g*? Here the procedure could, fortunately, be easier. I hold that, to facilitate subsequent vocational guidance, it is in everyone's interest that his amount of *g* should be assessed as accurately as possible quite early in life, and checked in subsequent years. Lest this should shock anyone I hasten to point out that, for about the last eighty years, assessments of some such sort have been made clumsily but regularly for educational purposes in all except the smallest schools in the

country. Children have always been graded into " fast " and " slow " sections, or into *A*, *B* and *C* forms. The situation, I suggest, should be that only about the top ·1 per cent. or so of the population from the point of view of *g* should be allowed to contemplate legislation as a career at all. It follows that sufficient inducement should be given to them to qualify first for the local, and then for the central, legislative bodies ; and this implies that they should at least stand to gain more by devoting their lives to public service than, say, by writing, producing, financing, displaying, or acting in, salacious films.

Clearly the position I contemplate resembles that of Plato's imagined Republic ; and also that depicted by Jesus the son of Sirach. Our counsellors should be men in whose constitution " the God " has blended gold ; not silver, or iron and brass (5). Of the last, who " trust to their hands ", I readily agree that " they will maintain the state of the world ", and that " without these cannot a city be inhabited." But I do think it elementary commonsense to ask that " they shall not be sought for in publik counsel " (6).

(E) Conclusion. So much for the general trend of my own present views on this important matter. The reader who wishes may work out his own solution of the same problem, and find an alternative method of securing legislation by people with sufficient *g*, and with the right *s*'s properly cultivated.*

* A possible improvement on my own scheme would perhaps lie in some more adequate devices to secure that no one had a hand in national legislation until he had proved himself capable of viewing national problems in relation to international ones ; and similarly with local problems in relation to national ones. This, superficially, may seem to run counter to my own scheme for practical training. I add it to illustrate the role of *s*. The problem would be this : How could the *s*'s for national legislation, which might have to be developed out of those acquired in local legislation, best be made large and rich enough to cope with national problems in the complex international contexts of life to-day, and, still more, in those of life the day-after-to-morrow ?

It may be, of course, that the reader does not share my prejudice that modern political issues are too subtle, too complex, and much too far-reaching in their effects, to be settled by Whipping Tom, Dick and Harry into lobbies; whether their motives for being within reach of the Whip are those of social ambition or of altruism. The reader may not hold my conviction that the last political amateurs, whether nourished on Latin with garnishings of cricket, or on the more realistic diet provided by a slum school and garnished in the gutter, should have been buried in the same grave twenty years ago. The first rumblings of the guns in August 1914 should, I earnestly believe, have been the volley fired at their common obsequies.

10. PROBLEMS OF UNIVERSAL SUFFRAGE

There is an allied political phenomenon, that of head counting, which is also worth thinking about in the light of *g* and *s*. Miss Smith and Miss Smythe have each slightly more than the average amount of *g*. However, while Miss Smith has very little leisure but occupies it in attending W.E.A. classes in economics, politics, sociology, and so on, Miss Smythe is completely leisured, but occupies hers in providing the pulpit with data for diatribes against the habits and inferred morals of modern youth. I submit it as self-evident that, when election time comes, Miss Smith's head is certainly worth counting, and that Miss Smythe's is barely worth boxing. If Miss Smythe be given a vote, then votes are certainly cheap enough to give Miss Smith a dozen or so.

The situation is not improved if one thinks of *g* rather than of the *s*'s. The Smythes' maid, for example, was in Standard IV when, at the earliest moment permitted by law, she left a school which made but the fewest pretensions to out-

standing scholarship. She has never heard of the W.E.A.; and spends her leisure on the same intellectual plane as her mistress though on quite another social one. *Her* head is counted at elections if she can find the necessary time to go to the booth and chooses to do so. Why ?

If politics have a tenth of the importance I personally attach to them, then the ablest men and women in the country must be given every possible inducement to study politics, and to participate " intelligently " in politics. It is far too much to expect a successful and busy doctor or lawyer to consider such matters at all, if the results of his deliberations are to be wholly annulled by any arch-cretin with the same electoral power, and with the fingers of some irresponsible Lord of the Popular Press in his sleeve. To the very people whose talents it should be most worth while to co-opt, a vote to-day is more nearly an insult than a privilege. The notion that, if you multiply one fool's folly by several thousand, wisdom will automatically emerge, seems so unrelievedly stupid to me that I find it impossible to understand how anyone can entertain it for longer than is required to grasp it. The only justification for the indiscriminate scattering of votes to all and sundry would be that the issues at stake were utterly devoid of importance. For my own part, except when there seems to be as clear a necessity for voting against a particular party " ticket " as that which led me to support the author-tipster already referred to, I eschew parliamentary politics. Like Robert, Prince of Wales, I prefer intellectual pursuits (7).

11. PROBLEMS OF THE POPULAR PRESS

A passing reference in the last paragraph may well be followed up, as it illustrates the application of the quantitative determinants to another very pressing problem of

modern life. It seems to me that from one point of view the popular press may be regarded as little more than a conditioning agency. By the exploitation, in particular, of the facts of constant output and facilitation, it has been brought about that, whenever two or three Registered Readers are gathered together in my hearing, their mere act of congregation becomes a conditioned stimulus, and their vocal reaction is of sport, or of the latest crime of violence. Again, I once had a landlady to whom Sunday evening acted as a stimulus to which her apparently mechanical response was an endeavour to obtain £1 a week for life by completing a crossword puzzle so puerile that it would scarcely embarrass an ordinary child of twelve were it not for the ambiguities which removed every vestige of skill and left only a chance of success so mathematically negligible that no one who was capable of the elementary arithmetic and slight effort necessary to evaluate it would have dreamt of prostituting even the insignificant amount of *g* the puzzle itself required.

Of facts and events of real importance, presented as such, without bias and without emotion, the random samples of the popular press which I periodically meet at the barber's contain few traces discernible to me. Instead of politics, as I think the word should be understood, I find the proprietor's latest slogan. Thus it is that the gibe that " There is much in the behaviour of other people, as when we are listening to a conversation on politics, for example, which gives no evidence of thinking, and which suggests that purely automatic reactions are taking place " (8), is so horribly deserved. The popular press to-day seems to me to be a parasite which preys on the intellects of those mentally feeble and unhealthy enough to harbour it. The eductive powers of the victim are inhibited. All that is left him is a power of reproducing, not even his own earlier eductions, but merely a version

of the proprietor's latest propaganda. He is as much "conditioned" as Pavlov's neurotic dog (page 158).

12. PROBLEMS OF TALENT AND REWARD

Examples of the application of our principles to practical affairs could be multiplied indefinitely. Those given so far have been chosen, not at random, but because they happen to be of particular interest to the present writer, and to strike him as having special importance. The following, an economic and sociological example of a large kind, is the last which space will allow. What seem to be its implications are only hinted at in order that the reader may have the opportunity of working them out more fully in his own way.

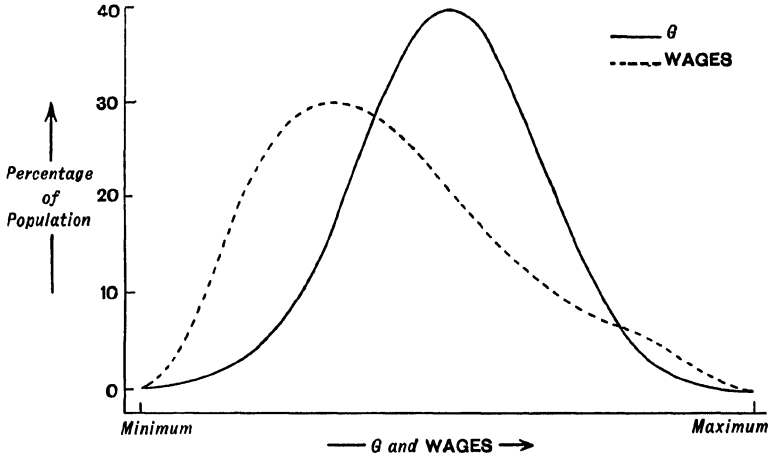

FIG. 43

Cattell gives Fig. 43 as illustrating the distribution of *g* and of wages among the population as a whole (9). Assuming no more than approximate accuracy to attach to the wages curve, (the *g* curve is definitely established), obvious problems arise.

1. How far is the discrepancy between the distributions of general ability and of remuneration due to orectic factors such as those of temperament and character?

2. What type of person (*a*) suffers most, and (*b*) gains most, from the lack of correspondence between the two distributions ?

3. (*a*) How far are discrepancies between *g* and reward avoidable, and (*b*) how far might it be to the real benefit of the community as such if any legislative or other steps possible were taken to effect closer adjustment ?

REFERENCES

(1) P. B. Ballard, *Mental Tests*, p. 23.

(2) W. James, *Psychology, Briefer Course*, p. 468.

(3) On this topic see F. M. Earle and others, *Methods of Choosing a Career* ; also Angus Macrae, *Talents and Temperaments* and *The Case for Vocational Guidance.*

(4) *The Human Factor*, July-August, 1934.

(5) *Republic* ; end of Book 3.

(6) *Ecclesiasticus*, 38, 24-34. The quotations are from vv. 31, 32 and 33.

(7) Bernard Shaw, *The Apple Cart*, Act 2.

(8) J. W. N. Sullivan, *Limitations of Science*, p. 169.

(9) *Psychology and Social Progress*, p. 94. (C. W. Daniel & Co.)

SUMMARY

WE hold, then, that success at any cognitive activity demands two factors, *g* and an *s*; and that the maximum degree of success possible to anyone at any such activity is limited by his *g* and (appropriate) *s*. But in ordinary circumstances the quantitative determinants tend to intervene; and, by affecting either *g* or the *s* or both, create a gap between potentiality and actual performance. The function of *g* when, under the restraint of the quantitative determinants, it activates an *s*, is to give rise to apprehension, to eduction, or to both. Apprehension is of one's lived experiences; eduction may be of relations, of correlates, or of both.

These basic principles are sufficient for the solution of the problems raised in traditional psychologies of cognition. In addition, they have applications in many practical fields, the scope and importance of which can not be overestimated.

APPENDICES

APPENDIX I

THE STATISTICAL ARGUMENT FOR THE TWO FACTORS

A: CORRELATION, AND CORRELATION COEFFICIENTS BETWEEN TWO TESTS

1. MEANING OF "CORRELATION".
2. CORRELATION "COEFFICIENTS".
3. THE INTERPRETATION OF r.
4. INTER-CORRELATIONS WITHIN A "BATTERY" OF TESTS.

B: TETRAD DIFFERENCES

5. THE TETRAD CRITERION DESCRIBED.
6. SATISFACTION OF THE TETRAD CRITERION.
7. NON-SATISFACTION OF THE TETRAD CRITERION.

C (8): CORRELATION WITH g

D (9): THE *TWO FACTORS* AND *SAMPLING* THEORIES COMPARED

THE statistical theorems which constitute the two factors theory of cognition are extremely technical and abstruse. The following is merely a simplified summary of the main steps in the argument, and contains no mathematical proofs (1).

A: CORRELATION, AND CORRELATION COEFFICIENTS BETWEEN TWO TESTS

1. MEANING OF "CORRELATION"

There are many pairs of phenomena which vary together from time to time, like a boy's age and his height; or from

place to place, like latitude and pigmentation of the skin; or from person to person, like height and weight; or in some other way. If the variations of one of the phenomena are found on the whole to go hand in hand with variations of the other, as certainly happens in each of the above instances, the two phenomena are said to be "correlated" with each other.

In psychology the phenomena whose correlations are investigated are usually test results; and these may record any conceivable variable aspects of the persons tested. They may measure age, height, wealth, "intelligence", or any other trait which, when measured, can be expressed as a number, which can in turn be used to place the persons tested in an order of merit for that particular trait.

Let us suppose that some test or other, which we will call Test "A", is applied to half-a-dozen persons. For the moment it does not in the least matter what trait "A" is supposed to measure. Let the result be as follows:

Candidate	Order of Merit at Test "A"
Brown	1
White	2
Green	3
Black	4
Pink	5
Grey	6

Now, let another test, "B", be applied to the same six candidates; and let the result be exactly the same, thus:

Candidate	Order of Merit at Test "A"	Test "B"
Brown	1	1
White	2	2
Green	3	3
Black	4	4
Pink	5	5
Grey	6	6

In ordinary language we should say that there is perfect agreement between the two sets of results; and we could

predict with complete confidence that a person who is good, mediocre or bad at either " A " or " B " will inevitably be *correspondingly* good, mediocre or bad (respectively) at the other. Mathematically it would be said that there is *perfect positive correlation* between the results of tests " A " and " B " when applied to these particular candidates.

Supposing that a third test, " C ", were applied to the same testees with the following results when compared with " A " (or " B ") :

Candidate	Order of Merit at Test " A "	Test " C "
Brown - - -	1	6
White - - -	2	5
Green - - -	3	4
Black - - -	4	3
Pink - - -	5	2
Grey - - -	6	1

This time there is complete *dis*agreement between the two sets of results. If " A " ranks a candidate high, " C " puts him correspondingly low ; and vice versa without exception. Mathematically we speak of there being *perfect negative* (or *inverse*) *correlation* between the two sets of results ; and we could predict with complete confidence that a person who is good, mediocre or bad at either test will inevitably be *correspondingly* bad, mediocre or good (respectively) at the other.

Here is a third possible example :

Candidate	Order of Merit at Test " A "	Test " D "
Brown - - -	1	3
White - - -	2	6
Green - - -	3	1
Black - - -	4	4
Pink - - -	5	2
Grey - - -	6	5

This time there is clearly little, if any, agreement between the two sets of results taken as a whole. They happen to concur in the single instance of Black's relative mediocrity ;

but it is clearly impossible to predict from a candidate's performance at either test what he would achieve at the other. Mathematically it would be said that there is *zero correlation* between the results of tests " A " and " D ".

2. CORRELATION "COEFFICIENTS"

This seems the place to remark on the mathematician's preference for expressing his facts by means of symbols and numbers. The letter r is used to denote a correlation ; and its magnitude, which can be calculated in several ways, is denoted by some number between $+1$ and -1. This number is called the *correlation "coefficient"*.

In the first of our three examples, that between " A " and " B ", where there was perfect positive correlation, it would be said that $r = +1$. In the second case, that between " A " and " C ", where the correlation is also perfect, but inverse, $r = -1$. In the third case, that between " A " and " D ", where there is no correlation at all, $r = 0$.

The usual convention is to use suffixes indicating the tests correlated ; so that in these examples,

$$r_{AB} = +1,$$
$$r_{AC} = -1,$$
$$\text{and } r_{AD} = 0.$$

These three are all, of course, extreme instances. In practice correlation coefficients never turn out to be such convenient whole numbers, but are always fractions, sometimes negative and sometimes positive. The following examples illustrate this :

Candidate	Order of Merit at Test " A "	Test " E "	Test " F "
Brown - - - -	1	3	5
White - - - -	2	1	4
Green - - - -	3	4	6
Black - - - -	4	2	1
Pink - - - -	5	6	3
Grey - - - -	6	5	2

Between tests "A" and "E" there is clearly some agreement. The candidates who are the best and worst at "A" *tend on the whole* to be those who are also best and worst (respectively) at "E". In this present example calculation shows that $r_{AE} = +\cdot 7$ (approximately). On the other hand it is obvious from an inspection of the rankings that tests "A" and "F" correlate inversely, for candidates who do well or badly at either *tend on the whole* to do badly or well (respectively) at the other. Actually $r_{AF} = -\cdot 6$ (approximately).

3. THE INTERPRETATION OF r

The question of the interpretation of a correlation coefficient must now be considered with care. First, it must be noted that we are dealing with variables of no less than four different kinds; and these must not be confused. They are as follow:

(1) Two traits (to be called A and B).
(2) Two tests (to be called a and b), one for each trait.
(3) Two sets of results (to be called α and β), one for each test.
(4) One correlation coefficient ($r_{a\beta}$)

The correlation coefficient measures the amount of agreement between the two sets of *results*; and we have to ask precisely what, if anything, it tells us about the two *traits*. When put explicitly in terms of practice rather than of theory, the question usually takes the following form: If, by experiment and calculation, we have found a large positive correlation (say, $r_{a\beta} = +\cdot 84$) between α and β, two sets of test results, what, if anything, are we entitled to infer about A and B, the two traits tested?

Now, since high, medium and low scores in α tend on the whole to go hand in hand with high, medium and low scores (respectively) in β, it is, on the face of it, *likely* that

the presence and absence of trait A are to some extent linked directly with the presence and absence (respectively) of trait B. The most important word here is "likely". The fact that $r_{\alpha\beta}$ is as high as $+\cdot 84$ *is not in itself sufficient to prove* that A and B are in any degree whatever directly linked one to the other. It is possible, though it is very rare, for a coefficient of this magnitude to occur between α and β merely by chance; that is, in the absence of any linkage whatever between traits A and B. But the probability that any given coefficient between α and β is a chance one, which does not represent a real direct linkage between A and B, is always calculable. In other words, it is always possible to say that there is precisely

1 chance in 3,
or 1 chance in 100,
or 1 chance in 10,000,

that the particular coefficient under consideration is, speaking colloquially, a *fluke*.

Let us suppose that the probability that $r_{\alpha\beta}$ is fortuitous has been calculated and found to be negligible. We may conclude, then, that the probability that A and B are in some manner (and to some ascertainable extent) directly linked to each other is sufficiently great that for practical purposes we can regard the linkage as adequately demonstrated. In such cases it is the convention to regard the linkage as *causal* in nature; and it is held that one of the three following situations must exist.

Either, (1) The presence of a certain degree of trait A, has *caused* the presence of a roughly corresponding degree of trait B;

or, (2) The presence of a certain degree of trait B has *caused* the presence of a roughly corresponding degree of trait A;

or, (3) There exists a third trait, say, Q, the presence of a certain degree of which has *caused* the presence of both trait A and trait B to degrees which roughly correspond with each other.

It is to be added, however, that in practice there is always a further check, and usually two such, on the suspected causality of an observed linkage between two traits. In the first place it is possible to form some idea of the nature of the linkage from the purely psychological point of view; that is, independently of merely statistical considerations. This applies particularly to the first two types of linkage listed above. In the second place, further traits can be tested, and the results correlated with α and β and with each other, and the statistical test (known as the *tetrad difference* criterion) to be described in Section B can be applied to detect the third type of causal linkage.

So much, then, for the interpretation of r, the correlation coefficient. We can define it and its function in the following way:

(1) Given (i) N persons, each of whom possesses two abilities, A and B.

Given also (ii) two tests, a (which measures A), and b (which measures B).

And given (iii) two sets of data, α and β, obtained by applying a and b, respectively, to each of the N persons.

It follows that $r_{\alpha\beta}$ *is a direct measure of the extent to which* α *and* β *go hand in hand.*

(2) We can infer from the magnitude of $r_{\alpha\beta}$ the extent to which A and B are causally connected if it can be shown statistically that there is a negligible probability that $r_{\alpha\beta}$ is due to merely irrelevant coincidence.

(3) This inference can be further supported

(i) if it can be shown by other, i.e. by non-statistical, methods that causal interdependence between A and B is *a priori* likely, and/or

(ii) if $r_{a\beta}$ and further r's obtained by testing the same N persons for abilities other than A and B, are found to satisfy the (*tetrad difference*) criterion shortly to be discussed (Section B).

4. INTER-CORRELATIONS WITH A "BATTERY" OF TESTS

Another point to note is that besides correlating A (p. 277) with each of the other tests B, C, D, E and F, we could also have correlated B with C, D, E and F; C with D, E and F; D with E and F; and E with F; giving a total of 15 inter-correlations between the six sets of results. When this is done, Table 1, containing 15 (duplicated) coefficients is the result.

TABLE 1.

	A	B	C	D	E	F
A -	—	+1	−1	0	+·7	−·6
B -	+1	—	−1	0	+·7	−·6
C -	−1	−1	—	0	−·7	+·7
D -	0	0	0	—	−·5	−·5
E -	+·7	+·7	−·7	−·5	—	0
F -	−·6	−·6	+·7	−·5	0	—

Turning from theory to practice, we must now note the facts which are observed when this method of correlation is applied to data actually obtained by the testing of cognitive traits. In general we can state two things:

(1) That such abilities *are* found to correlate among themselves to varying extents.

(2) That the actual coefficients are almost always positive.

Table 2 is quite a typical example. For the present discussion the precise significance of the terms "controlled association", "selective judgment", and the rest, does not matter. All that is of moment is that each is the name given to a measurable cognitive trait, and that the coefficients are all so high that, even though there were no psychological, or further statistical, evidence that the traits were causally connected, yet none the less we should be entitled to infer this about them.

TABLE 2: Inter-correlations of mental traits (2).

	Mathematical judgment	Controlled association	Literary interpretation	Selective judgment	Spelling	Average
	1	2	3	4	5	
1. Mathematical judgment	—	·485	·400	·397	·295	·394
2. Controlled association	·485	—	·397	·397	·247	·382
3. Literary interpretation	·400	·397	—	·335	·275	·352
4. Selective judgment - -	·397	·397	·335	—	·195	·331
5. Spelling - -	·295	·247	·275	·195	—	·253
Average -	·394	·382	·352	·331	·253	—

B: TETRAD DIFFERENCES

5. THE TETRAD CRITERION DESCRIBED

When the coefficients in such a table of inter-correlations as 2 satisfy a certain criterion, it inevitably follows that success at the tests correlated (that is, at those listed at the edges of the table) is determined by causes of two kinds. These causes are usually called the *factors* of the abilities or traits concerned; and the two kinds are termed *general* and

specific. The general factor is a single one which affects every one of the abilities concerned. It is usually symbolized by the letter "*g*", and is "general" in the sense of being common to them all. The other sort of factor, called the "*s*", will be represented several times, once for each ability; and is "specific" in that each specimen of it affects only one ability. Alternatively, we may say that if the inter-correlations of *n* tests obey our criterion, then the *n* abilities concerned depend upon *n* + 1 factors, *n* of which are specific, one to each ability; the odd one being common to them all.

Now we come to the question, what *is* this criterion? By name it is that of *tetrad differences*. It consists in taking all the possible tetrads from a table of inter-correlations, cross-multiplying, and seeing whether the differences between the products thus obtained approximate sufficiently to zero. This needs elucidation. A tetrad consists of any four co-efficients which form the corners of a rectangle in a table of inter-correlations. Thus we could take this four from Table 2.

	Controlled association	Spelling
Mathematical judgment - -	·485	·295
Literary interpretation - -	·397	·275

or this

	Literary interpretation	Spelling
Controlled association - -	·397	·247
Selective judgment - -	·335	·195

The criterion is that the difference between the two products obtained by cross-multiplication should, in every tetrad in the Table, *tend* to be zero. Thus, in the first of the two tetrads just given, the two products will be

$$·485 \times ·275 = ·133375$$

and

$$·397 \times ·295 = ·117115$$

and the difference between the products will be

$$\cdot 133375 - \cdot 117115 = \cdot 016260$$

In the second example the products are

$$\cdot 397 \times \cdot 195 = \cdot 077415$$

and

$$\cdot 335 \times \cdot 247 = \cdot 082745$$

and the difference between these products is

$$\cdot 082745 - \cdot 077415 = \cdot 005330$$

Thus, in these two examples, though neither tetrad difference is exactly 0, both are extremely small. Their precise magnitudes will be discussed more fully in a moment. For the present we can sum up the position we have arrived at by saying that n abilities can be regarded as caused by one general factor plus n specific ones if, and only if, all the possible tetrad-differences in the complete table of intercorrelations between the abilities are approximately zero.

In Table 2, where 5 abilities are concerned, there are 15 possible tetrads; that is, 15 groups of four coefficients rectangularly arranged. The fifteen tetrad differences are as follow (Table 3):

TABLE 3

·001
·003
·004
·005
·005
·010
·016
·018
·019
·021
·023
·026
·031
·032
·035

6. SATISFACTION OF THE TETRAD CRITERION

A fresh difficulty arises here. Although these 15 tetrads are all extremely small, not one is exactly 0. It has, then, to be asked whether they are sufficiently near enough to 0 to justify the conclusion that the 5 abilities correlated (in Table 2) can be completely accounted for in terms of one general and five specific factors. In actual research work a mathematical test has to be applied to any set of differences to see whether they approximate to 0 closely enough for this inference to be drawn. But this mathematical test is much too complicated and technical an affair for discussion in a book of this character.* Here it is proposed instead to compare the tetrad differences we obtained from Table 2 with those which appear when the traits measured are not mental, but physiological. A suitable Table is the following (4):

TABLE 4. Inter-correlations of physiological traits (3).

	Weight	Height	Area of ossification	Lung capacity	Nutrition	Average
	1	2	3	4	5	6
1. Weight - -	—	·69	·62	·39	·83	·63
2. Height - -	·69	—	·60	·51	·11	·48
3. Area of ossification	·62	·60	—	·31	·26	·45
4. Lung capacity -	·39	·51	·31	—	·26	·36 (8)
5. Nutrition - -	·83	·11	·26	·26	—	·36 (5)
6. Average -	·63	·48	·45	·36 (8)	·36 (5)	—

Here it may be noted that the actual coefficients are generally much higher than those obtaining between tests of mental traits (Table 2). † Again, in this Table, there

* Its application is, however, illustrated in Fig. 45, p. 294.

† This average is ·458, that of Table 2 is ·294.

are 5 traits, 15 tetrads and 15 tetrad differences. These last are listed in Table 5 :

TABLE 5

·020
·023
·060
·082
·096
·099
·102
·111
·122
·137
·156
·244
·319
·380
·430

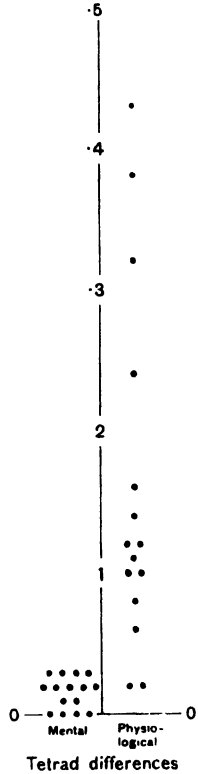

FIG. 44

For convenience, the two sets of differences (Tables 3 and 5) are plotted (correct to 2 places of decimals, only) in Fig. 44.

From it this it is clear that, on the whole, correlations between these mental traits do, and correlations between these physiological traits do not, tend to satisfy the tetrad difference criterion. But, since as far as experimentation has gone these tendencies have been found to be normal, it may be asserted that a cognitive trait is typically analysable into a general and a specific component, and that a physiological trait is typically not so analysable.

7. NON-SATISFACTION OF THE TETRAD CRITERION

Here it must be added that we are faced only with tendencies, and not with inevitably occurring facts. Even in the two examples we have just considered, it is noteworthy that one of the differences in the mental Table (2) is as great as ·035 ; while in the physiological Table (4) two are as

small as ·02. The problem is to determine the conditions which operate when, in the case of mental traits, the tetrad-difference criterion is not satisfied. We may already infer that the four abilities concerned are not explicable as being solely dependent on one general and four specific factors. An analysis of a particular example will be of help here. Let it be the following tetrad, which has the largest difference in Table 2 :

	Controlled association	Literary interpretation
Mathematical judgment - -	·485	·400
Spelling - - - - -	·247	·275

Here the difference is $(\cdot485 \times \cdot275) - (\cdot400 \times \cdot247)$ . . .(*a*)

$= \cdot133375 - \cdot098800$ . . . . . .(*b*)

$= \cdot034575$

$\doteq \cdot035$

Clearly, the reason for such a large difference is that the first of the two products in (*b*) is too great *compared with* the second.* Arguing backwards, it follows that one at least of the two coefficients in the first pair of brackets in (*a*) is disproportionately large. In this particular example it is the correlation between spelling and literary interpretation which is anomalous. It is exceptionally high (·275), too high to be explained as due to the general factor alone. If *g* were alone responsible for the correlation between spelling and literary interpretation that particular coefficient would be only ·204, for $(\cdot485 \times \cdot\mathbf{204}) - (\cdot400 \times \cdot247) \doteq 0 \cdot 0$.

To what, then, is this extra correlation between spelling and literary interpretation due ? Put in more general terms the question becomes this : When the tetrad criterion is not satisfied owing to the presence of an exceptionally high coefficient, what is to be held accountable for this extra

* In actual fact a tetrad difference of only this magnitude may be expected to occur once, merely by chance, in a Table of 15 tetrads.

correlation which is over and above that due to the general factor, *g*? Much research has been devoted to this problem in the several forms in which it has arisen. Here it is proposed to give merely the answer, none of the detail. Such an extra correlation is only explicable as being due to "overlap" of the two specific factors (*s*'s) involved. In other words, the two traits which have been tested and correlated are so similar that there is a partial identity of the mechanisms, probably neural in character, which subserve them. In the example we have been considering these were linguistic activities; and, as such, are found to be more closely allied to each other than either is to such a trait as that of mathematical judgment.

C: CORRELATION WITH G

(§ 8) When a "battery" of tests of *g* has been devised on theoretical or any other grounds (or even, as seems quite frequently to have happened, on no grounds whatever) it is of obvious importance to be able to determine the degree of accuracy with which the component tests measure *g*. This is done in the following way. Let *A*, *B*, *C*, *D*, and *E* be any 5 tests in the same battery; let success at each be determined by *g* and an *s*; let all the *s*'s be wholly independent; and let $r_{Ag}=\boldsymbol{a}$, that is, let $\boldsymbol{a}$ represent the degree to which *A* would correlate with a theoretically perfect measure of *g*.

In a similar manner, let $\boldsymbol{b}$, $\boldsymbol{c}$, $\boldsymbol{d}$, and $\boldsymbol{e}$ be respectively equal to r_{Bg}, r_{Cg}, r_{Dg} and r_{Eg}.

Now it has been shown, but the theorem is complex in the extreme, that the actual inter-correlation which will be obtained in practice between any two of the tests, say, between *A* and *B*, will be $\boldsymbol{ab}$, the product of the two theoretical coefficients, $\boldsymbol{a}$ and $\boldsymbol{b}$.

Similarly, the actual value obtained for r_{AC} will be ac,

..... r_{AD} ..... ad,

..... r_{AE} ..... ae,

etc.,

and lastly..... r_{DE} ..... de.

Table 6 summarizes this:

TABLE 6

TEST:		A	B	C	D	E
Correlation with g		a	b	c	d	e
TEST	Correlation with g					
A	a	—	ab	ac	ad	ae
B	b	ab	—	bc	bd	be
C	c	ac	bc	—	cd	ce
D	d	ad	bd	cd	—	de
E	e	ae	be	ce	de	—

It now becomes possible, the products ab, ac, ad, etc., having been determined experimentally in the course of an actual investigation, to obtain the important values a, b, c, d and e. For example, a can be found by substituting in any of the following formulæ:

$$a=\sqrt{\frac{ab\,.\,ac}{bc}},\ \text{or}\ a=\sqrt{\frac{ab\,.\,ad}{bd}},\ \text{or}\ a=\sqrt{\frac{ab\,.\,ae}{be}},$$

$$\text{or}\ a=\sqrt{\frac{ac\,.\,ad}{cd}},\ \text{or}\ a=\sqrt{\frac{ac\,.\,ae}{ce}},\ \text{or}\ a=\sqrt{\frac{ad\,.\,ae}{de}}.$$

Taking the first formula as an example, elementary algebraic manipulation gives,

$$\sqrt{\frac{ab\,.\,ac}{bc}}=\sqrt{\frac{a^2bc}{bc}}=\sqrt{a^2}=(\pm)\,a.$$

Similarly for all the other formulæ for ***a***; and subsequently for ***b***, ***c***, ***d*** and ***e*** as well.

If, then, we have a Table giving the inter-correlations of 5 tests, there are 6 different ways in which we can discover the extent to which each test would correlate with a perfect measure of *g*. When inter-correlations obtained from actual experimentation are employed, the different formulæ, say, for ***a*** (i.e., for r_{Ag}) do not give identical values; but in a well-constructed test they will be very close, and it is sufficient to take their mean as indicating the degree of correlation existing between *g* and the test under consideration.* In this connection it is worth referring again to Table 2 in order to determine the extent to which each of the 5 sub-tests is, on the average, correlated with *g*; that is, to determine their relative merits as measures of *g*. Table 7 repeats the figures of Table 2, but the letters *A* to *E* have been substituted for the names of the tests to bring it into line with Table 6.

TABLE 7

	A	B	C	D	E
A	—	***ab*** = ·485	***ac*** = ·400	***ad*** = ·397	***ae*** = ·295
B	***ab*** = ·485	—	***bc*** = ·397	***bd*** = ·397	***be*** = ·247
C	***ac*** = ·400	***bc*** = ·397	—	***cd*** = ·335	***ce*** = ·275
D	***ad*** = ·397	***bd*** = ·397	***cd*** = ·335	—	***de*** = ·195
E	***ae*** = ·295	***be*** = ·247	***ce*** = ·275	***de*** = ·195	—

* There is a simple statistical device which can be employed to test whether or not the mean of any collection of data is an acceptable representation of their probable central tendency.

From the above figures we can obtain the following values for a, that is, for r_{Ag} :

$$a = \sqrt{\frac{ab \,.\, ac}{bc}} = \sqrt{\frac{\cdot 485 \times \cdot 400}{\cdot 397}},$$

$$\text{or } a = \sqrt{\frac{ab \,.\, ad}{bd}} = \sqrt{\frac{\cdot 485 \times \cdot 397}{\cdot 397}},$$

etc.

When worked out these values are as follow (Table 8) :

TABLE 8

·6551
·6886
·6964
·6990
·7610
·7750

The mean of these values for r_{Ag}, or a, is ·71238 ; and so it can be taken that test *A* correlates with a theoretically perfect measure of *g* to the extent of (approximately) ·71.

Table 9 gives the mean values of the correlations of each of the tests with *g*.

TABLE 9

$r_{Ag} = a = \cdot 71$
$r_{Bg} = b = \cdot 67$
$r_{Cg} = c = \cdot 62$
$r_{Dg} = d = \cdot 55$
$r_{Eg} = e = \cdot 40$

D: THE TWO FACTORS *AND* SAMPLING *THEORIES COMPARED*

(§ 9) Fig. 45 gives the following curves showing the distribution of tetrad differences arising in the Brown and Stephenson research referred to in the text (page 227) (**4**) :

Curve (A) : Tetrad differences *actually* obtained.

Curve (B) : Tetrad differences to be expected according to the *two factors* theory.

Curve (C): Tetrad differences to be expected according to the *sampling* theory.

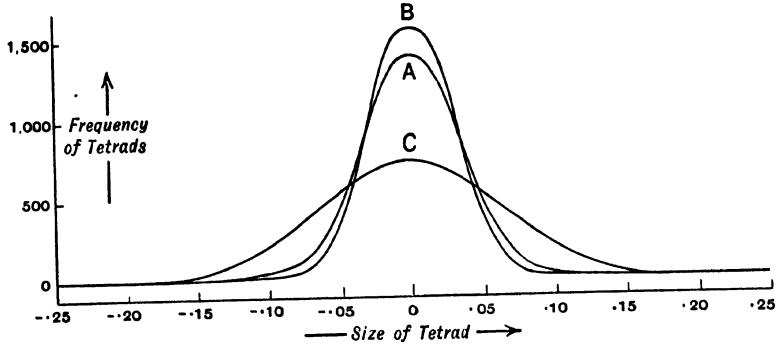

FIG. 45

REFERENCES

(1) Proofs are to be found in AM, pp. i-xxiii.

(2) Bonser, BJP, July 1912, and AM, p. 147.

(3) Gates, *Journal of Educational Research*, 1924, and AM, p. 143.

(4) *Psychology and Psychotherapy*, 3rd edition, p. 243, William Brown. (Edward Arnold & Co., Ltd.)

APPENDIX 2

RELATIONS

A: REAL RELATIONS

1. ATTRIBUTION.
2. IDENTITY.
3. TIME.
4. SPACE.
5. CAUSE.
6. OBJECTIVITY.
7. CONSTITUTION.

B: IDEAL RELATIONS

8. LIKENESS.
9. CONJUNCTION.
10. EVIDENCE.

SPEARMAN distinguishes relations of ten different kinds (1); of which (*A*) seven are said to be REAL and (*B*) three IDEAL or RATIONAL. Examples of each kind follow.

A: REAL RELATIONS, that is, those obtaining between the intrinsic characters of the things related

1. ATTRIBUTION

Fig. 46 gives rise to the percept of a black circle. Taking the percept as a whole, we may say that blackness and roundness are attributes of it. That is, *relations of attribution* hold between (1) the blackness and the black circle, and between (2) the roundness and the black circle.

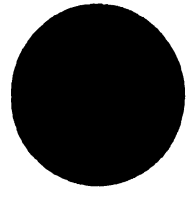

FIG. 46

In general, the attributive relation holds between any character of an experience and the experience itself.

2. IDENTITY

If the reader will glance back to Fig. 46 it will be found to be identical with the figure seen there a few moments ago. We may say that the *relation of identity* can be educed from such a pair of experiences as this.

3. TIME

Words like *after*, and *soon*, indicate *temporal relations*. For example, between any two auditory experiences that are not apprehended simultaneously, the relation of *succession* may be educed.

4. SPACE

Certain relations may be called *spacial*; those, for example, indicated by such words as *above*, *below*, *beside* and *within*. Thus, from cognition of the two items of Fig. 47, the spacial relation of *verticality* can be educed.

5. CAUSE

The *causal relation* holds between an act of will and the ensuing conation; or between a conative activity and the change in cognitive intensity which it induces. It is also popularly said to hold between certain physical events; for example, between the striking of one object by another, and the subsequent movement of the former.

6. OBJECTIVITY

This is, perhaps, the best name to give to the sort of relation which exists between any object and the cognition of it; between what is willed and the willing of it; or between a thing desired and the acceptance of it as desirable. Alternatively, such relations have been termed *psychological*.

7. CONSTITUTION

There is another relation which, in Fig. 46, holds between the blackness and the roundness on the one hand, and the perceived black-circle on the other; this is the relation of *constitution*. The blackness and roundness between them constitute the percept, and bear to the whole the relation of constitution. (None-the-less, the attributive and constitutive relations are quite different, and should not be confused. Fatherhood, for example, bears the *attributive*, but not the *constitutive*, relation to father.)

B: IDEAL or RATIONAL RELATIONS, namely, those obtaining between things themselves

8. LIKENESS

Relations of *likeness* and *unlikeness* may be educed in a variety of ways between the characters of one cognized item and those of another. For example, between the visual items of Fig. 47 the relation of likeness can be educed with respect to blackness and flatness; and that of unlikeness with respect to shape and size.

9. CONJUNCTION

The relation of *conjunction* is represented in language by such expressions as *and, plus, also, in addition to, together with*, and *in conjunction with*. This relation is the foundation of the whole of arithmetic; with that of identity, of the whole of algebra; and, together with the relations of spaciality, it forms also the basis of geometry. The relation of conjunction may be educed between the separate percepts of Fig. 47; the latter, in conjunction with one another, giving rise to the idea of *two*.

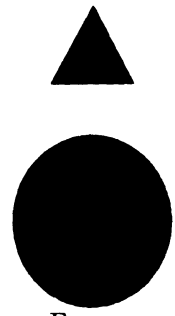

FIG. 47

10. EVIDENCE

In the two following examples, relations of evidence have to be educed between the data on the one hand and the proffered "solutions" on the other, in order to select the correct one from among the latter.

1. I was the last to arrive, but shall be the first to go away. Two arrived before me; how many will go away after me?

None? One? Two? Three?

2. Tom started long before Dick, and Dick at the same time as Harry. I started just after Harry. Who started first?

Tom? Dick? Harry? or *I?*

REFERENCE

(1) Cf. NP, chap. 5 and AM, chap. 12.

APPENDIX 3

THE DIFFUSION OF LEARNING EFFECTS

1. Introduction.
2. The Problem.
3. Nomenclature.
4. The Contrasted Solutions Proffered.
5. The Inevitable Conclusion.
6. A Modern Instance of the Diffusion Fallacy.
7. The Evidence of Experiment.
   (*A*) Conclusions to be drawn from experiments on practice.
   (*B*) Comparisons between practice and training.
8. Diffusion and the Present Standpoint.
9. Conscious and Unconscious Diffusion.
10. Conclusion.

1. INTRODUCTION

The problem dealt with here is an old one, which was settled long ago. There are, however, two justifications for re-opening the discussion. First; a great many people whom it concerns, appear to be quite unfamiliar with it (Cf. § 6). Secondly; the problem has not yet, so far as the present writer is aware, been dealt with as a rider to the factor and noëgenetic theories. The following treatment, then, is probably novel; even though no new data are adduced.

2. THE PROBLEM

The problem is simply this. If you wish to learn to drive a motor car, is it of advantage to learn Latin first? Or, again; if you hope to become a successful detective, is a course in geometry likely to help? And, for the last example; how far is proficiency at knitting a useful foundation upon

which to build up a really successful career as a crochet expert ?

3. NOMENCLATURE

The problem is usually known as that of the *transfer of training*, a title which is not particularly apt since, as often as not, it is the transfer of mere practice which is meant. Further conventional titles are, *formal training* and *mental discipline*, neither of which is self-explanatory to the novice ; and *reciprocal improvement in learning*, which is little better. There are also many others, having various degrees of merit. The one used here, *diffusion of learning effects*, is completely apt, and its meaning is self-evident.

4. THE CONTRASTED SOLUTIONS PROFFERED

The saying that " the Battle of Waterloo was won on the playing fields of Eton " seems to represent one extreme view of the matter. Bernard Shaw's " No man ever learns to do one thing by doing something else, however closely allied the two things may be " (1), certainly represents the opposite. According to the first view, the most potent stimulus to the acquisition of whatever qualities make for success as a military officer in action, is the compulsory games system of the English Public Schools.* Shaw would presumably hold that the same qualities can only be acquired in actual warfare.

5. THE INEVITABLE CONCLUSION

Pending the time when statesmen succeed in engineering the next opportunity of testing these two hypotheses in

* This seems to be at any rate the most usual interpretation of the saying under discussion, despite the fact that compulsory games were not introduced into the Public Schools until long after 1815. (I should like to express my thanks to my friend Mr. F. A. Bailey for having pointed this out—it had quite escaped my notice.) This historical point does not, however, affect the present issue.

practice, one must turn to experimental evidence collected in connection with analogous problems in other fields than those of battle. Of such evidence there is an abundance; and there is no ambiguity about its significance. Shaw's view is so much nearer the truth than the other that, for practical purposes, it is best accepted almost without qualification. It is a general rule that practice in one activity makes only negligible contributions (if any at all) to improvement at others, even though the latter may be very similar; although, when suitable training is substituted for practice, the situation may be, and sometimes is, improved.

6. A MODERN INSTANCE OF THE DIFFUSION FALLACY

The more enlightened reader may feel at this point that the present writer is flogging a horse as dead as any dodo, or even as Anne herself. There would be some truth in such a criticism. But, none the less, dead though this unfortunate animal may really be, yet, in the words of a once popular song, he just "won't lie down". The corpse is not yet cold; *rigor mortis* sets in but slowly; even occasional writhings may still be seen. The following, for example, has appeared quite recently (under the heading *On Learning Latin*) as "an extract from a letter in the correspondence columns of the *Observer* over the name of a well-known ex-headmaster—himself a Science man".

"The study of the classics had, and has, one quite peculiar value, in that it deals with an expression of human experience which is once for all finished and unchangeable. All rules are definite, and all exceptions established in the known literature. The result is that the mind acquires both a pre-

cision and a flexibility which the study of no language or science which is still in the course of development can give.

" I used, when persuading the parents of able boys to place them on the classical side, as opposed to the modern or scientific side, to go as far as to say this :

" ' If I were in a runaway motor-car, and the driver had to dodge a dog, put his foot on the right one of three pedals and show presence of mind in handling the steering wheel, the prayer I should put up would be : I hope this fellow has learnt Latin.'

" My opinion was backed up by my experience with foreign bankers, engineers, industrialists. They all agreed that, for the first year or so, the boy from a special technical school seemed better for their purpose than the boy from the classical high school ; but that two such boys very soon drew level, and that in five years' time the boy of wide general humanistic education was infinitely the better in dealings both with problems and with people."

In addition, one learns from the source in which the above was quoted that, " Latin is methodical : in this lies one of its many virtues. It tends to produce an orderly mind."

7. THE EVIDENCE OF EXPERIMENT

(A) Conclusions to be drawn from experiments on practice. Now that we have dutifully inspected the corpse, and seen for ourselves that it still writhes, it is time to cease flogging, and to hold an inquest. It has been said already that a vast amount of evidence has been collected to throw light on one or other aspect of the problem. Cognitive performances of all kinds, from such simple ones as cancelling certain letters of the alphabet from a page of text, to such complex ones as the ordinary school subjects, have been employed as the

practice or training activity; and the effects of these on success at other, sometimes very similar and sometimes quite dissimilar, test activities, have been assessed many times.

The evidence concerning practice effects is collected and scrutinized in many places, particularly in works on educational psychology, where, usually, accounts of the rather complicated technique required by investigations into these problems are also to be found. As we are only concerned with the conclusions which have been drawn from the evidence, the reader is referred to such works for the actual experimental details (2). An appreciable amount of the evidence has been unequivocally negative; that is, investigators have failed to find any indications at all that the practice effects of the first activity diffuse and contribute to improvement in the second. Occasionally, even, it has been found that practice at one activity actually has deleterious effects on others. But the general experience of investigators is that *slight* helpful diffusion usually takes place if one or more of the following situations exists:

(1) An identity of the *material* used in the practice and test activities.

(2) An identity of the *methods* required by the two activities.

(3) The formation, during the practice activity, of *ideals* which are later applied successfully in performing the test activity. Such ideals as those of neatness, self-criticism, industry, exactitude, veracity, co-operation, freedom from bias and personal animus, of dispassionate scientific inquiry, and very many others, may emerge from any study conducted with a suitable outlook; and they are transferable with profit to any other activity whatsoever.*

* The present writer has, in this list of ideals, gone considerably beyond the available experimental evidence. The underlying principle is, however, established.

(B) Comparisons between practice and training. Some of the experimental work in which the effects of training have been compared with those of mere practice are very illuminating. Three examples are given here.

(1) Training in memorizing one sort of material was found to be vastly superior to merely unguided practice in memorizing the same sort, when the effects of both on the memorization of a second sort were tested (3).

(2) Training boys in the process of defining the terms met with in their physics lessons has been found to help them in defining ordinary words. Comparable boys who did the same physics course without special emphasis on the nature of definitions showed no improvement in their capacity to define ordinary words (4).

(3) "Skill, developed by the mere repetition of one manual operation, confers little advantage on the performance of other operations that may be subsequently undertaken. Where, on the other hand, repetition is replaced by suitable instruction, the skill thus developed . . . tends to transfer to other operations over a fairly wide range of manual activity" (5).

8. DIFFUSION AND THE PRESENT STANDPOINT

It would seem, then, to be well established that, if you wish to improve a particular cognitive activity, you must either practise it, or study the technique it demands, or apply to it any appropriate ideals which you may have found from experience to have value in other activities. On the other hand it is quite futile to spend time in cultivating some other activity in the expectation, or even in the hope, that the proficiency you acquire will automatically diffuse

from this to the first. If you are anxious to think clearly in matters, say, of politics, then your time should be given to politics. Geometry, classics and crossword puzzles should be eschewed; except they be indulged in as recreations, or for their own sakes.

When diffusion occurs and is traceable to identity of the methods required by the practice and test activities, the underlying mechanism can be found in the eduction of rela-

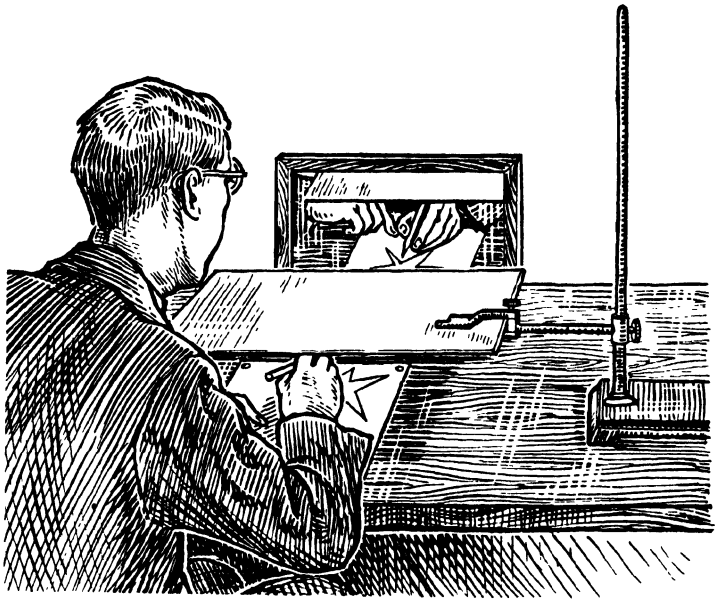

FIG. 48

tions and correlates. The mirror drawing experiment described on page 70 and illustrated in Fig. 48 can be used to make this point clear. Begin by tracing the figure with the left hand; then practise several times in succession with the right hand; and, lastly, make one more attempt with the left hand. It will be found that practice effects transfer from the right hand to the left. The following results were obtained for the left hand before and after the nine right-hand trials recorded in Fig. 5 (page 71).

	Before right-hand practice	After right-hand practice	Percentage improvement
(*a*) Number of seconds taken	146	64	+56%
(*b*) Number of errors - -	91	58	+36%
(*c*) Area of error in square millimetres	90	102	−13%

The inference is fairly clear. Data (*a*) and (*b*) suggest that the subject had learnt from his experience with the right hand what methods to adopt with his left; and (*c*) indicates that he required practice with the left hand itself before he could make full use of what had been learned; (*a*) and (*b*) show that he had grasped the complex spacial relations involved whether it be the right or the left hand which is used; (*c*) shows that the left-hand *s*'s had not been facilitated during the right-hand practice.

It is only necessary to try this experiment oneself in order to see that, in this particular instance, the identity of method between the two (right- and left-hand) tasks is reducible to explicit (spacial) relation and correlate eduction.

The application of the principles of eduction to other problems of common-method-diffusion are left to the reader. It is not difficult to see, for example, why book-keeping should be better than elementary Latin as a means of enhancing one's powers of "selective and relational" thinking (6). But advanced Latin, that is, Latin by the time it has reached the stage in which the early emphasis on mere retention and reproduction has been replaced by an emphasis on subtle eductions, ought surely to be better than book-keeping for the same purpose. (Cf. pages 187-189.) The most important point of all still remains, of course, namely, that *neither produces any effect large enough to be worth bothering about in practice.*

In experiments where stress is laid on the acquisition of technique, diffusion is, as we have seen, more prone to occur; and here, again, the mechanism appears to be that of relation and correlate eduction. Relations explicitly educed in simple or complex training situations can be applied in test situations; and a successful response can be educed directly as a correlate instead of being left to empirical discovery. If one learns, for example, the respects in which a tentative definition of some physical term falls short of perfection, this knowledge is clearly usable in framing other non-physical definitions. One might start by defining a *magnet* as " an iron bar shaped like a horseshoe". It may then be grasped explicitly that this definition is inadequate, since not all such bars are magnets; and otherwise inaccurate, since magnets may have quite different shapes. All this may be of obvious help in preventing the term *laughter* from being defined as, say, " the human response to amusing situations ".

Even the diffusion of practice effects from one activity to another involving material of the same kind seems to require explicit eduction for its explanation. Two boys, shall we say, know the meaning of the word " sympathetic ". The one who learns Greek will also know that the prefix *a* means " not "; and the one who does not may miss this information. The first will then be in a better position than the second to educe that " unfeeling " is a possible meaning of " apathetic "; also that this word is bound to be spelt with only one *p* and not with two. (It seems *a priori* possible, however, that *s*-overlap may be, if not an actual *sine qua non* for diffusion of this type, yet at least a potent agency in contributing to it. But it seems by no means as likely that the converse is true. Such work as that cited in § 7 (*B*) 3, for example, makes it practically certain that even slight auto-

matic diffusion is not an inevitable consequence of mere *s*-overlap.)

Ideals, such as those mentioned in § 7 (*A*) 3, belong to the realm of orexis ; and their detailed discussion lies, therefore, outside our present scope. They are, however, referred to in each of the remaining paragraphs.

9. CONSCIOUS AND UNCONSCIOUS DIFFUSION

The most prominent fallacy in the long quotation given in § 6 is that diffusion takes place to an extent that would justify parents in giving their able boys a classical rather than a modern or scientific education. Another fallacy is, of course, that classics is more prolific of diffusion than other school subjects. And yet a third is that diffusion, whether it be large or small in amount, takes place automatically. Latin, it is claimed, " tends to produce an orderly mind ", which also acquires " precision and flexibility ", whether the learner wishes his mind to have these qualities or not. Similarly, the motorist, it seems, cannot help dodging dogs better for knowing Latin. And, boys from the " classical high school " are apparently powerless to avoid being " infinitely . . . better " than boys from a " special technical school " for longer than five years.

It should be clear from the present discussion that such automatic and unconscious diffusion as has been detected, is *always* negligible in amount ; and may even be limited to cases of *s*-overlap. The fundamental cognitive mechanism of diffusion is eduction ; and diffusion only takes place to a significant extent when the processes of eduction are conscious and explicit.

10. CONCLUSION

There is an abundance of other fallacies lurking in views of which those quoted in § 6 are typical samples. An

important one lies in the failure to distinguish between effects due to the learner himself, and those due to what is learnt. It has already been stressed more than once, for example on pages 30 and 187, that, of the usual school studies, that of the classics demands more *g* than does any other. In consequence it is only the ablest, the most " intelligent ", scholars who excel at, and are inclined to pursue, it. The effect is that there is a general tendency for such people to succeed at a wider range of other activities than do those who start and abandon classical studies, or who have never been thought able enough to be given an opportunity to begin them. But their success is due to superior *g*, and not to the classical studies themselves. And they would have lost none of their general ability had they studied poultry farming instead of Latin, and raffia-work instead of Greek. The fallacious and true views are depicted diagrammatically by (*a*) and (*b*), respectively, in Fig. 49.

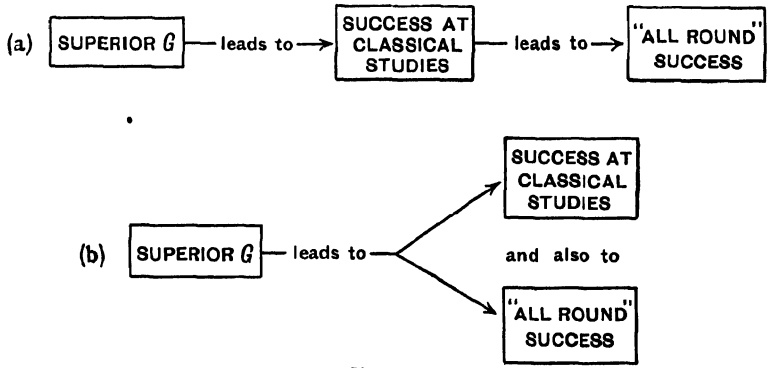

FIG. 49

A further fallacy lies in the uncritical and uncomprehending use of the term " mind " in such clichés as " tends to produce an orderly mind ", or, a " precise and flexible mind ". In discussing this fallacy the writer is faced with two alternatives. Either he must embark upon a lengthy discussion of the meaning of the word " mind ", and so pass

from psychology into metaphysics ; or else he must translate the fallacy into the terms with which these pages have made the reader familiar. No apology is made for adopting the second alternative. The fallacy lies in making an assumption which all the evidence shows to be erroneous ; namely, that *g* is educable. To say, for example, that " geometry tends to produce an analytical mind " would mean either nothing whatever, or else that, after one has pursued a course in geometry, one's *g* has undergone a qualitative change which has made it more capable than before of dealing with a particular type of problem. All the evidence is against any such assumption. *G*-differences between people, and within the same person as he advances towards maturity, are quantitative, not qualitative ; and are determined by inheritance, not education. Euclid's entire output could not make Tennessee take the book *Genesis* at anything except its face value, nor evolution as anything but a blasphemy. But, and this is the most important point of all, what a man does with his geometry depends only in part upon his *g*. It depends also upon himself ; upon his own ego ; upon the deepest and most vital orectic factors. He may learn it and leave it. Or he may derive from it ideals of perseverance ; of rigorous examination of basic facts ; of persistent seeking after what is relevant, and of rejecting what is not ; and, especially, of dispassionate, scientific inference : and all of these, fortunately, are of universal applicability. And he may do this whether he has much *g* or little. Truly, the more *g* he has, the better he will be able to do it, *if he does it at all.* But not even the doing of it can add a hair's breadth to *g* itself, or improve its non-existent quality.

Lastly, he would be no more than a rash and uninformed speculator, or an incorrigible partisan, who would maintain

that geometry, or classics, or any specific study, provides *better* opportunities than others for spreading the contagion of such ideals. This is a unique contagion, from which some people enjoy unqualified immunity, though they spend their lives in an atmosphere which they themselves declare to be impregnated with it more potently than any other. The catching of it depends wholly on the man himself, and not on the atmosphere he breathes, whether this be scientific or literary, classical or modern.

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(1) *The Perfect Wagnerite.*

(2) An excellent account is to be found in *Educational Psychology*, chap. 14 ; Peter Sandiford.

(3) H. Woodrow, *Journal of Educational Psychology*, 1927.

(4) G. P. Meredith, *Forum of Education*, 1927.

(5) J. W. Cox, BJP, July 1933.

(6) One of the conclusions which emerged from what Sandiford describes as " Thorndike's crucial experiment ". Sandiford, *op. cit.*, p. 292 *et sqq.* ; Thorndike, JEP, 1924.

APPENDIX 4

RETENTIVITY IN THE SPECIAL SENSES *

By ELSA WALTERS, B.A., PH.D.

1. SUBJECT OF INVESTIGATION.
2. SUBJECTS.
3. MATERIAL.
4. METHODS.
5. RESULTS.
6. CORRELATION WITH *g*.
7. EFFECT OF CONATIVE EFFORT.

1. SUBJECT OF INVESTIGATION

The analysis of the factors involved in remembering sensory stimuli.

2. SUBJECTS

Fifty Secondary school girls, aged 9 years 9 months to 12 years 8 months, underwent each test.

3. MATERIAL

As far as possible non-logical, nonsense material was used, no names being used for the stimuli. Visual material consisted of colours, which were indefinite in hue, and simple but meaningless diagrams. Auditory material consisted of nonsense syllables (i.e., " words " such as *miv*, *vop*, *zeg*, etc.), and tactual material of card-board shapes which were handled, with both hands, unseen. For the gustatory tests liquids of differing and indefinite, though distinct, flavours were used; and corked test-tubes containing cotton wool saturated with various chemical compounds tested olfactory memory. In all except the gustatory and olfactory tests two sets of material were used, each consisting of thirty items, sixty in all. This enabled a measure of reliability to be found.

* Summary of Ph.D. Thesis (1929) in the Library of the University of London.

4. METHODS

The visual and auditory tests were given to groups of about twenty subjects, all the others were taken individually. In each case ten stimuli were presented in succession at appropriate intervals. Immediately after this, a series of thirty was presented, containing the ten original stimuli mixed in irregular order with twenty others, the subject being required to indicate whether she had or had not experienced each before. This was repeated three times for each sense, using a different group of ten stimuli each time. Each answer was, when marked, given one point if correct, whether an affirmative for a stimulus which had been experienced, or a negative for one which had not.

5. RESULTS

The scores for memories of each sense were inter-correlated, using the Bravais-Pearson (" product-moment ") formula. The original coefficients are given with their probable errors in Table 1. When corrected for attenuation (where statistically allowable) a similar result is obtained.

TABLE 1. Inter-correlation of retentivities for different sensory data.

	Diagrams	Auditory	Tactual	Gustatory	Olfactory
Colours	·448 (·07)	·369 (·08)	·24 (·08)	−·141 (·09)	·2 (·09)
Diagrams		·35 (·08)	·38 (·07)	−·093 (·09)	·157 (·09)
Auditory			·237 (·08)	−·082 (·09)	·345 (·08)
Tactual				·276 (·08)	·42 (·07)
Gustatory					·29 (·08)

Overlap is indicated by the figures in heavy type.

These data afford evidence of overlap between memories of

(*a*) things seen and heard

(*b*) things seen and handled, and

(*c*) things touched, tasted and smelled.

It is noteworthy that these correlations exist between senses which are related in perception. Apart from these three instances it would appear that the factors of sensory retentivity are wholly specific to the sense involved.

6. CORRELATION WITH *g*

The same subjects were tested for *g* by Spearman's *Measure,** and the resulting mental ratios correlated with the scores for retentivity. Positive correlation was found in almost all cases, but it was obvious that, though the material was chosen to be as meaningless as possible, absolutely nonsense material could not be obtained. To the extent, then, that the material had meaning, *g* as well as retentivity was involved in learning. Certain tests were therefore repeated in such a manner that scores could be obtained for immediate and delayed memory, and the difference between them was taken as a truer measure of retentivity. This, when correlated with *g*, gave :

$$r = -\cdot 078 \pm \cdot 094$$

This confirms other findings that there is no correlation between *g* and pure retentivity.

7. EFFECT OF CONATIVE EFFORT

The subjects were divided into two equal age groups, and the group tests repeated. The first group took the tests as

* *A Measure of "Intelligence" for Use in Schools*, C. E. Spearman. (Methuen, 1925.)

before, as part of the ordinary school routine, with little comment. The second group was told the original individual scores, and discussed the possibility of trying hard to improve. Prizes were promised to those making the greatest improvement, and at each experiment further urging and encouragement was given.

TABLE 2. Effect of conative effort on retentivity.

Effort Group	1st Attempt	2nd Attempt	Difference (2nd-1st)
Visual test-Mean	- 63·107	68·475	+5·268 (=8·3%)
Auditory test-Mean	- 65·28	70·50	+5 22 (=8·0%)
Control Group			
Visual test-Mean	- 60·75	66·95	+6·2 (=10·2%)
Auditory test-Mean	- 60·6	66·35	+5·75 (= 9·5%)

The figures are the mean scores (maximum—90), and the differences between the means. The latter are all significant.

Improvement appears, therefore, to be slightly greater when *no* special effort is made. Conative effort not only does not improve powers of retentivity but even seems to create a slight handicap. This may be referred to the principle of the constancy of cognitive output; mental energy which should go to cognition being partly diverted to the effort, and partly, perhaps, to some ensuing emotional disturbance as well.

INDEX OF NAMES

n = footnote *s* = et seq.

A

Abelson, 53
Arai, 84, 90 *n*
Archimedes, 4-**3**
Aristotle, 72-**6**
Aveling, xiii *s*, 13 *n*, 166 *n*
  on mental set, 100 *n*, 241-**14**

B

Ballard, 258-**3**, 274 *n*
Barrett, 67 *n*
Bartok, 124
Berg, 124
Bernstein, 83 *n*
Bonser, 294 *n*
Brown, 189 *n*, 224, 243 *n s*, 294 *n*
  on sampling theory, 253
  on two factors and sampling theories, 293 (**D**)
  on validity of the tetrad criterion, 225-**3** *s*
Burt, 111 *n*
  on reasoning power in children, 108-**11**

C

Camp, 224
Cary, 53 *n*
Cattell, 189 *n*
  on racial differences in *g*, 105-**5**
  on surgent-desurgent temperament 20 (**B**)
  on talent and reward, 273-**12**
Collar, 53 *n*
Cox, 48, 53 *n*, 311 *n*
Crichton-Miller, 13 *n*, 111 *n*

D

Dawson, 224
Delius, 257
Dunne, 182 *n*
Dvorak, 156-**6**

E

Earle, 274 *n*
Einstein, 2, 178, 257
Euclid, 178, 310

F

Fisher, 224
Flecker, 67 *n*
Florence, 265 *n*
Flügel, 94 *s*
Fox, 24
Freud, xvii
  on dreams, 75 (**B**), 214 (**B**)

G

Garnett, 83 *n*, 228 (**A**)
Gates, 294 *n*
Gosse, 172 (**C**), 182 *n*

H

Hadfield, 13 *n*, 111 *n*
  on suggestion, 75 (**B**)
Haliburton, 41 *n*
Hardy, 11-**4**
Hazlitt, on intelligence, 156 *n*
  on purpose, 239-**12**
  on relevance of relations, 236-**10**, 250 (**B**)
Herbart, 72-**6**
Hertz, 159 (*II*)
Heywood, 225
Hume, 175-**6**
Huxley, 133-**3**

I

Irwin, 224
  on indeterminacy of *g*, 229

J

James, 259-**5** *s*, 274 *n*
Jesus the son of Sirach, 269
Jourdain, 182 *n*
Jung, 214 (**B**)

K

Kelley, 53 *n*
  on two factors theory, 252 (**C**)
Knight, 24 *n*
Köhler, 166 *n*
  on behaviour of apes, 157 *n*
    hens, 159 (*I*)
Kreisler, 104-**3**
Krueger, 53 *n*

L

Lashley, 166 *n*
  on behaviour of rats, 157-**7** (**A**)
  on musical transposition, 168 *n*
Locke, 207-**2**
Long, 219 *n*
Lucretius, 188

M

Macrae, 274 *n*
McDougall, 13 *n*, 166 *n*
  on behaviour of wasps, 160 (**C**)
  on hormic psychology, 248-**5**
  on nature of *g*, 228 (**A**)
  on validity of two factors theory, 225
  " Spot-Dotting " apparatus, 92-**2**
McDowell, 41 *n*
  on non-significance of consciousness, 235 *n*
Mendel, 3-**2**
Meredith, 311 *n*
Moberly, 182 *n*
Moul, 226-**5**, 244 *n*, 253
Mount, 53 *n*
Mozart, 257
Murchison, 245-**1**

N

Newton, 2, 136, 178

P

Paderewski, 104-**3**
Pavlov, 72-**6** *s*, 158 (*II*), 166 *n*, 236, 273
Pear, 53 *n*
Pearson, 226-**5**, 244 *n*, 253
Peterson, 53 *n*
Philpott, 93-**5**, 95 *n*
Piaggio, 224
  alternative proof of the two factors theory, 225
  on indeterminacy of *g*, 228 (**B**)
  on sampling theory, 252 (**B**)
Pinard, 83 *n*
Plato, 269
Potts, 111 *n*

S

Saloz, 40-**7**, 105
Sandiford, 311 *n*
Seashore, 53 *n*
Shaw, 274 *n*, 311 *n*
  on differences in ability, 14 *s*
  on diffusion of learning effects, 300-**4**
  on politics, 271
Spearman, xiii *s*, 23, 30-**9** (**A**), 53 *n*, 56 *n*, 67-**7**, 111 *n*, 130 *n*, 182 *n*, 189 *n*, 194, 220 *s*, 225 *s*, 232-**8** *s*, 243 *s*, 314-**6**
  contribution to psychology of, 260-**6**
  intellectualistic outlook of, 256-**2**
  on behaviourism, 248 *n*
  on conative control, 100 *n*
  on definition of concept, 204-**1**
  on dreams, 214 (**B**)
  on fusion and confusion in concept formation, 209 *n*
  on immediate remembrance, 212
  on indeterminacy of *g*, 229
  on intensity and determinateness of cognition, 196
  on laws of cognition, 243-**16**
  on noëgenesis, 182 (**C**)
  on notion of animateness, 202-**4**
  on notions of God and the infinite, 207
  on notion of unconsciousness, 179 (**D**)
  on oscillation, 94-**6**
  on perseveration, 211
  on qualitative principles, 135 *n*
  on recollection of information, 210
  on relations, 295
  on retention, 127, 212
  on sampling theory, 252 *n*
  on scientific concepts, 206 (**C**)
  on sex differences, 109
Spitta, 219 *n*
Stephenson, 53 *n*
  on test of two factors theory, 227, 253, 293 (**D**)

Stevanovic, 145 *n*
Sullivan, 147 *n*, 274 *n*
  on absence of thought processes in Behaviourists, 235 *n*
  on automatic reactions, 272
Syrus, 67 *n*

T

Thouless, 64
Thomson, on indeterminacy of *g*, 229
  on sampling theory, 252 (**B**)
Thorndike, 94, 244 *n*, 311 *n*
  and anarchic theory, 226-4, 246
  views of ability of, 251 (**A**)

W

Walters, xix
  on retentivity, 50 *n*, 312 *s*
Watson, 72-6 *s*, 248 *n*
Webb, 53 *n*
Wilks, 224
Wilson, 224 *s*
Wishart, 224
Woodrow, 311 *n*
Woodworth, 245-1, 254 *n*
Wundt, 14
Wynn-Jones, 83 *n*

INDEX OF WORKS

(excluding periodicals) referred to in the text

The Abilities of Man, Spearman, 24 *n*, 32 *n*, 53 *n*, 67 *n*, 83 *n*, 90 *n*, 95 *n*, 100 *n*, 111 *n*, 120 *n*, 224, 254 *n*, 294 *n*, 298 *n*.
Ability, Hazlitt, 156 *n*, 240, 244 *n*
An Adventure, Jourdain and Moberly, 182 *n*
The Apple Cart, Shaw, 274 *n*

Back to Methuselah, Shaw, 16 *n*
Behaviorism, Watson, 76 *n*
Brain Mechanisms and Intelligence, Lashley, 168 *n*

The Case for Vocational Guidance, Macrae, 274 *n*
Character and Intelligence, Webb, 53 *n*
Conditioned Reflexes, Pavlov, 76 *n*, 166 *n*
Contemporary Schools of Psychology, Woodworth, 245-1
Creative Mind, Spearman, 182 *n*, 233
Crossroads in the Mind of Man, Kelley, 53 *n*, 254 *n*

Directing Mental Energy, Aveling, 13 *n*, 100 *n*, 156 *n*

Ecclesiasticus, 274 *n*
Educational Psychology, Fox, 24 *n*
Educational Psychology, Sandiford, 311 *n*
Educational Psychology, Thorndike, 244 *n*
The Energies of Men, McDougall, 13 *n*, 166 *n*
An Experimental Study of . . . Judgment, Stevanovic, 145 *n*
An Experiment with Time, Dunne, 182 *n*

Father and Son, Gosse, 172 (C)
Fluctuations in Human Output, Philpott, 95 *n*

Gestalt Psychology, Köhler, 166 *n*
The Golden Bough, Frazer, 76 *n*
Group Intelligence Scale, Cattell, 189 *n*

Handbook of Physiology, Haliburton and McDowell, 41 *n*
Hassan, Flecker, 64, 67 *n*

Intelligence and Intelligence Tests, Knight, 24 *n*
Introduction to Social Psychology, McDougall, 13 *n*

Lessons in Elementary Physiology, Huxley, 135 *n*
The Limitations of Science, Sullivan, 235 *n*, 274 *n*

Manual Skill, Its Nature and Organisation, Cox, 53 *n*
The Measurement of Intelligence, Thorndike, 254 *n*
A Measure of "Intelligence" for Use in Schools, Spearman, 56 *n*, 189 *n*, 314 *n*
Mechanical Aptitude, Cox, 53 *n*
Mentality of Apes, Köhler, 157 *n*
Mental Tests, Ballard, 274 *n*
Methods of Choosing a Career, Earle, etc., 274 *n*
The Mind, Edited McDowell, 235 *n*

The Nature of "Intelligence" and the Principles of Cognition, Spearman, 100 *n*, 182 *n*, 203 *n*, 209 *n*, 219 *n*, 244 *n*, 298 *n*

On Dreams, Freud, 76 *n*

The Perfect Wagnerite, Shaw, 311 *n*
Practice, Fatigue and Oscillation, Flügel, 95 *n*
Psychical Research, Barrett, 67 *n*
Psychoanalysis and Its Derivatives, Crichton-Miller, 13 *n*
Psychological Types, Jung, 24 *n*
Psychologies of 1925, Edited, Murchison, 76 *n*
Psychologies of 1930, Edited, Murchison, 53 *n*, 76 *n*, 245-1, 254 *n*
Psychology and Morals, Hadfield, 13 *n*, 76 *n*, 111 *n*
Psychology and Psychotherapy, Brown, 189 *n*, 225-3, 243 *n*, 294 *n*
Psychology and Social Progress, Cattell, 111 *n*, 274 *n*
Psychology, Briefer Course, James, 274 *n*
Psychology from the Standpoint of a Behaviorist, Watson, 76 *n*

Quickness and Intelligence, Bernstein, 83 *n*

The Republic, Plato, 274 *n*

The Statistical Method in Economics and Political Science, Florence, 265 *n*
Straight and Crooked Thinking, Thouless, 67 *n*

Talents and Temperaments, Macrae, 274 *n*
Tess of the D'Urbervilles, Hardy, 11-4
A Treatise of Human Nature, Hume, 175-6

INDEX OF SUBJECTS

n = footnote *s* = et sqq.

A

Abilities, alleged independence of, 22-3
  association between, 22-3
Ability, all-round, 20 (**B**), 43-2
  anarchic views of, 22-3 *s*
  arithmetical, 49 (*III*) *s*, 109-12
  basic two-fold nature of, 52
  bi-focal view of, 24
  clerical, 262
  constructive, 46 (**B**)
  contradictory views of, 22-4
  energy-engine hypothesis of, 54-1, 116
  general, 18. See also *G*
  general determinants of, 120
  individual differences in, 14
  linguistic, 40-7 *s*, 109, 262
  manipulative, 263-8
  mechanical, 40 (**B**), 52-7, 109-12, 262
  monarchic view of, 17-1, 23-5
  musical, 18, 31, 108, 257
  nature of, 23
  non-focal views of, 23-5
  oligarchic views of, 18-2, 23-5
  problems of, 14, 23, 57
  physiological aspects of, 54-1
  quantitative aspect of, 20 (**B**)
    determinants of, 58
  social, 49 (*II*)
  superior, 103, 106, 109-13 *s*, 309
  theories of, 31-10
  two factors theory of, 23 *s*
  uni-focal view of, 23-5 *s*
  up-and-down movements of, 92-2
  variations in, 57, 70-4
  verbal, 109
  views of "types" of, 23-5
  voluntary improvement of, 36-4
Abnormal mental conditions, 8. See also *Pathology*
Abstraction, 13, 198-3 (**A**)
Abstract ideas and "intelligence," 18
  "intelligence," 251 (**A**)
  thought, 40-7
Absurdity, 214 (**B**)
Achromatic sensations, 137 (**A**) *s*
Acceptance. See *Volition*
Accidents, 263-8
Acquiescence, 207-2
Acquisition of language, 41, 171 (**B**) *s*
  of skill, 259-5 *s*, 307
Activity. See also *Self-activity*
  purposive, 142
Acuity, auditory, 93-4
  sensory, 106-6
Adaptibility, 18
Addition, 49 (*III*), 87-4, 94
Admiration, 9 (**B**), 143-7
Affection, 9 (**B**) *s*
Affective competition, 63-4
  elements in religion, 64
Age, 119-4, 253 (**C**)
  and *g*, 102-2
  and quantitative determinants, 105-4
  and *s*, 104-3
Alcohol, effect of neural stimulation by, 214 (**B**)
Alertness, 142
Algebra, 297-9
Algesic sensations, 138
Alpine races, 106
Altruism and ambition, 270
Amount of *g*, 55
Anæsthesia, 110-14
Analysis of experience, 11 *s*
  of traits, 288 *s*
Anarchic theory, 22-3 *s*, 226-4, 232, 251 (**A**)
  and *s*, 32 (**B**)
  validity of, 32 (**C**)

Anger, 9 (**B**)
Animal psychology, 71-**5**, 140-**2**, 204, 235 *n*
Anoëgenetic processes of cognition, 123, 182 (**D**), 192
Anxiety, 9 (**B**)
Aphasia, 40-**7**, 110-**14**
Appetite, 10-**3**
Apprehension of experience, 136 *s*, 168, 174-**5**, 179 (**D**) *s*, 183-**2**, 190, 194 *s*, 211, 230 *s*, 250, 260-**6**, 275
  quickness of, 82-**5**
Arithmetic, 49 (*III*) *s*, 297-**9**
Arithmetical abilities, overlap among, 49 (*III*)
  ability, 52, 109-**12**
Artistic temperament, 20 (**B**)
Assent, 10 (**D**), 66. See also *Volition*
Association, 63, 72-**6**, 104-**3**, 109-**12** *s*, 113 (**B**) *s*, 126 *s*, 158 (*II*), 163, 171, 191 *s*, 208, 213-**3**, 236. See also *Reproduction*
  between talents, 22-**3**
  controlled, 284
  fluency of, 21
  mathematical. See *Correlation*
Atomic theory of inheritance, 3-**2**
Atrophy of brain tissue, 41
Attention, 19, 125-**3** (**A**), 142, 194 *n*, 259-**5**
Attenuation, 226-**4**, 313-**5**
Auditory acuity, 93-**4**
  cognition, 60, 168-**2**
  imagination and memory, 19
  sensations, 138
Australian Blacks, 106
Authority, 208
Automatic writing, 66 (**B**)
Awareness, 146-**1**, 164, 167-**1**, 178 (**C**). See also *Self-awareness*
  dawn of, 134-**4**
  distribution of, 59, 66 (**B**), 117 (**C**)
  heightening of, 96-**2**
  imageless, 205 (**B**)
  " immediate," 144-**8**
  movements in and out of, 92-**3**
  threshold of, 143
Awe, 9 (**B**), 143-**7**

B

Background of consciousness, 9 (**B**), 12-**5**, 62, 141
Balance, organs of, 39 (**C**)
Bankruptcy, 267
Basic conditions, 101 *s*, 119-**4**, 191, 253 (**C**) *s*
  and constant output, 110-**16**
  processes, complex products of, 19
Bat, squeak of, 137 (**A**)
Battery of tests, 283-**4** *s*
Behaviourism, 72-**6**, 234-**9**, 245-**1** *s*
Bi-focal view of ability, 24
Biological view of " intelligence," 18
" Bird-rabbit " illusion, 153
Birds, behaviour of, 159 (**B**)
  nest building of, 71-**5**
Birth of knowledge, 121, 181 (**B**), 241-**13**
Blackness, 137 (**A**)
Black-whiteness, 138, 151 (**C**), 197
Blended emotions, 9 (**B**)
Blood constitution, inheritance of, 36-**4**
  stream, 118-**3** (**A**)
    and *g*, 227-**6**
    and brain, 34-**3** (**A**)
Bodily condition, 109-**13**
Book-keeping, 306
Boredom, 87-**4** *s*, 114 (**D**), 118 (**E**)
Brain, 112-**1**, 132, 144-**8**, 259-**5**
  activity and consciousness, 34-**3** (**A**)
  cells and *g*, 35 (**D**), 227-**6**
    and *s*, 41
    defective, 35 (**D**)
    vicarious functioning of, 41
  disease of, 40-**7**
  injury, effects of, 36-**4**, 110-**14**
Breakdown, nervous, 158 (*II*)
Broad factors, 50-**6**, 56-**3**, 252 (**B**)
Broad-shallow " type," 82

C

C, 82-**5**, 119-**5**
Capacity, variations in. See *o*
Car driving, 208, 263-**8**, 299-**2**, 302, 308-**9**
  and *g*, 63-**3**, 72

Cause, 281
the First, 178 (C)
Cellular tissue. See *Brain* and *Neurones*
Central nervous system. See *Brain* and *Neurones*
Chance, 281, 289
Character, 82-5, 109, 273-12
Characters, isolation of, 204-1 (A)
of experience, 137-1, 141, 147-2, 151 (C), 295-1
Cheerfulness, 82-5
Child psychology, 73-7, 108-11, 172 (C), 214
Choice. See *Volition*
Chromatic sensations, 137 (A) *s*, 197
Chronaxie, 119 *n*
Chronic liability to fatigue, 88-5 (B)
Clarity of cognition, 196
Classics. See *Latin*
Clearness variation, 123, 128, 130 *n s*, 182 (D), 192
Clergy, 267
Clerical ability, 262
Cleverness, 82-5, 119-5
Coefficients. See *Correlation*
Cognition, 6, 8-2 (A), 11-4 (A) *s*, 257. See also *Control of cognition*
and imagination, 217
and orexis, 10-3
anoëgenetic processes of, 123, 192
auditory, 60, 168-2
birth and growth of, 241-13
characters of, 195-1
clarity of, 196
extent of visual, 59
fundamental principles of, 249-6
inhibition of, 64, 212-2
intensiveness and extensiveness of, 96-2
intensity of, 137-1 *s*, 195-1, 212
of novel experiences, 199
prerequisites of, 132
quality of, 124-2, 137-1, 195-1, 243-16
quantitative laws and determinants of, 58 *s*
spacial and temporal characters of, 137-1 *s*
Cognitive activities, failure in, 57, 69-2
competition, 61-2 *s*
configurations, 249 (A)
constructs, 175, 206 (C)
deterioration, 104-3
efficiency, 75, 80, 84 *s*, 89-6, 99-6, 110-16
role of *g* and *s* in, 57
variations in. See *Oscillation*
elements in mental "types," 21
energy, 52-4, 116-1, 121, 186, 253 (C)
engines, 116-1, 121
equivalents, 118
error. See *Error*
experience, 143, 147
failure, 33 *s*, 57, 69-2, 113 *s*, 187, 192
growth, 250 (B)
improvement, role of *g* and *s* in, 37, 104-3
inertia, 77-2 *s*
intensity, 115 (F), 296-5
output, constancy of, 59
curve of, 94
processes, 140-2, 168-3
success, 81, 94, 115, 183-1, 192, 275
role of *g* and *s* in, 33 *s*
traits, correlations between, 283-4 *s*
analysis of, 288
variability, 91, 114 (E), 116-2 (A), 191. See also *o*
Collective consciousness, 206
Colour, 138
discrimination, 109-12
Combination of concepts, 207-2
Common elements among *s*'s. See *Overlap*
sense, 17-1
Competition, mental, 61 *s*
Complementary laws, 4-3
Complex emotions, 9 (B), 143-7
Complexity of *g*, 227-6
of *s*, 37-5, 51
Complex products of basic processes, 19, 194 *s*
Comprehension, 140-2
Compulsory games, 300-4

Conation, 9 (C) *s*, 64, 77-1, 100 *n*, 115 (F), 141-4 *s*, 177, 228 (A), 248-4, 296
and retentivity, 314-7
inhibition of, 118 (E)
Conative competition, 65-5
control, 96-2, 117 (C), 123-1 (A), 126, 145, 231 *n*
Concentration, 142
Concept, definition of, 204-1
Conception, 102-2
Conception, 140-2, 204 *s*
Concepts, combination of, 207-2
formation of, 204 *s*
scientific, 206 (C)
Conditioning, 73-7, 158 (*II*), 235 *s*, 247-3, 272
Confidence, 9 (B)
Configurations, mental, 249 (A)
Confluence, 154-5, 194 *n*, 249 (A)
Connector neurones, 37-5 *s*
Conscientiousness, 100
Conscious control of cognition, 96-1
diffusion of learning effects, 308-9
experience, types of, 8-2
unity of, 12-5
phenomena, 235
processes, 7
Consciousness, 133-3. See also *Awareness*
and brain activity, 43-3 (A)
background to, 9 (B), 12-5, 62, 141
collective, 206
function of, 235 *n*
in ability, role of, 16
threshold of, 127
Constancy of cognitive output, 59 *s*, 72, 79 (B), 86, 91 *s*, 113 (A), 117 (D), 124-2 *s*, 162, 191, 205, 212 *n*, 242-15, 264, 272, 315
and basic conditions, 110-16
and memory, 62 (C)
Constitution of blood, 36-4
Constructive abilities, overlap among, 46 (B)
Contiguity, association by, 163
Contrast, association by, 163
Control. See also *Self-control*
hormic, 237 *n*
inhibition of, 118 (E)
of cognition, 96, 100, 117 (C), 126, 145, 148, 191, 212 *n*, 216, 237, 248
Controlled association, 284
Controversy over *g*, 246
Coördination, muscular, 231 *n*
Correction formulæ, 223, 225-3
Correlate eduction, 163, 167 *s*, 184, 190, 194, 203, 214 *s*, 228, 233 *s*, 250, 275, 305 *s*
and perception, 198-3
double process of, 176
Correlates, 147, 169
eduction of correlates from, 175
mathematical, 173 (D)
transcendental, 174-5, 233
Correlation, 82-5, 95, 109-13, 251 (A), 283-4 *s*. See also *Inter-correlation*
coefficients, 276 *s*, 313-5
discussion on, 224
due to *g*, 43-2 (A)
due to overlap, 44 (B), 47
intercolumnar, 223, 225-3
Creativeness, 213-3, 218, 233
Cretinism, 34-3 (B) *s*
Criteria of an acceptable law, 5-4
Criticisms of the two factors theory, 223
Crossword puzzles, 170-4, 272
Cure of drug addict, 76

D

Data, mathematical analysis of, 3-2
Dawn of awareness, 134-4
Day dreams, 213 (A)
Death, 102 *n*, 256 *n*
Decision. See *Volition*
Deduction, 209
Deep-narrow " type," 20 (B), 82
Defective brain cells, 35 (D).
Deficiency, mental, 34-3 (B)
inheritance of, 107-8
Definitions of " intelligence," 18
Delayed memory, 314-6
Depression, 82-5
Desire, 10-3, 141

Despair, 9 (**B**)
Desurgency, 20 (**B**), 82
Detection of overlap, 43-**2**
Deterioration of brain tissue and *g*, 36-**4**
of *s*, 38 (**A**)
Determination. See *Volition*
Determining tendency. See *Mental set*
Determinants of cognition, quantitative, 58
Determinateness of cognition, 196, 205
of recollections, 212-**2**
Development of *g*, 103
Dexterity, digital and manual, 49
Diet, 36-**4**
Differences in ability, 14
in *g*, 310
tetrad. See *Tetrad differences*
Difficulty, 142
Diffusion, conscious and unconscious, 308-**9**
of learning effects, 299 *s*
Digital dexterity, 49
Discipline, mental, 300-**3**
Discontent, 262
Discrete mental " powers," 18-**2**
Discrepancy beteen *g* and remuneration, 273-**12**
Discrimination, sex differences in sensory, 109-**12**
Disease of brain, 40-**7**
effect on *g*, 36-**4**
Disgust, 9 (**B**), 143-**7**
Disintegration, formation of concepts by, 204-**1** (**A**)
Disparition, 130 *n*
Disposition, unconscious. See *Mental set*
Dissociation, 66 (**B**)
Distribution of awareness, 59, 66 (**B**)
of *g* and wages, 273-**12**
Divine Revelation, 182 *n*
Division, 49 (*III*)
Dogs, 73-**7**, 158 (*II*)
Dreams, 75 (**B**), 111
day, 213 (**A**)
symbolism in, 214 (**B**)
Drug addict, cure of, 76
Duration of experience, 139 (**D**)
Dynamic nature of sensation, 195-**1**
Dynamics, 136

E

E, 230
Early training, 107 *s*
Ears, 138
and balance, 39 (**C**)
Eclectic nature of the two factors theory, 32 (**C**)
Educability, 18
Education, 72-**6**, 252 (**B**), 308-**9** *s*
Eduction, 183, 209, 230, 241-**14**, 246, 260-**6**, 275
and *g*, 183-**2**
and " intelligence," 185-**3**
explicit, 306
formation of concepts by free, 206 (**C**)
implicit and explicit, 239-**12**
impossible varieties of, 218
of correlates. See *Correlate eduction*
of relations. See *Relation eduction*
Eductive power, 227-**6**, 253 (**C**)
inhibition of, 272
Effector neurones, 37-**5** *s*
organs, 37-**5** *s*, 104-**3**
Efficiency, role of *g* and *s* in, 57. See also *Cognitive efficiency*
variations in. See *Oscillation*
Effort, 10 (**D**), 142
Ego, 66, 142-**6** *s*, 310
Egoism and imagination, 213 (**A**)
Election to Parliament, 266 *s*
Electrical energy, analogy of, 55, 117 (**D**)
Electric charge on electron and proton, 230
Emotion, 75 (**A**) *s*, 114, 143-**7**, 215 *s* 257, 272
and thought, 64
Emotional disturbance and retentivity, 315
elements in religion, 64
meanings, 64
Emotions, blended, 9 (**B**)
complex and simple, 9 (**B**), 143-**7**
Endeavour. See *Conation*
Endocrine glands, 16
Energy, 228 (**A**)

Energy-engine hypothesis, 54-1, 116
G, and analogy of electrical, 55, 117 (D)
undifferentiated cognitive, 54-2
Environment, 16, 36-4, 107 (*ii*) *s*
Equivalents, cognitive, 118
Error, 156 *n*, 161-8, 172
sampling, 229
stamping in of, 69-2
Errors, typographical, 60, 73-7, 150, 242
Ether, 132, 144-8
Excitement, 85-2, 88-5 (A)
Existential psychology, 245-1 *s*
Experience. See also *Apprehension of experience*
analysis of, 11 *s*
characters of, 141, 147-2, 151 (C), 295-1
cognition of novel, 199
hedonic, 143, 147
intensity of, 151 (C)
limitations of, 180-7, 202-4
lived. See *Lived experience*
localisation of, 139 (C)
mystical, 182 *n*
possibility of transcending, 180-7, 202, 213-3
quality of, 151 (C)
sensory, 137-1 *s*
spacial character of, 151 (C)
temporal aspect of, 139 (D), 151 (C), 211
types of conscious, 8-2
undifferentiated, 134-4
unity of conscious, 12-5, 197
Experimental investigation, 21, 25, 260-6
Experiments in animal psychology, 73, 157 *s*
in child psychology, 73
on association, 164
on clearness variation, 123
on cognitive competition, 61 *s*
on conative competition, 65
control, 96 *s*, 123
on conditioning, 73
on correlate eduction, 170-4 (A) *s*, 184 *s*
on diffusion of learning effects, 302-7 (A) *s*
on distribution of awareness, 59
on facilitation, 70, 305
on fatigue, 84, 88
on imagination, 215 (C) *s*
on oscillation, 92 *s*
on perception, 198 *s*, 232-8 *s*
on perseveration, 79
on practice and training, 304 (B)
on relation eduction, 151 *s*, 184 *s*, 236-10 *s*
on retentivity, 312 *s*
on sentience, 134
on two factors theory, 225-3 *s*, 293 (D)
on volitional control, 241-14 *s*
" Explanations," scientific, 2
Explicit relation eduction, 162, 166 (C)
Extension, 139 (C)
Extensiveness of cognition, 96-2
Extroversion, 20 (B), 82
Eye, 42, 132, 138
as functional part of an *s*, 38 (A)

F

Facilitation, 68 *s*, 84, 104-3 *s*, 113 (B), 118-3 (B), 126 *s*, 145 *s*, 162, 208, 231 *n*, 236 *s*, 264, 272
and activities not requiring *g*, 71-5
of isolated events, 68, 191
of paired events, 72, 191
Facility of learning, 246
Factors, 193, 235 *s*, 247-2 *s*, 256 *s*, 284-5
broad and group, 50-6, 56-3
general, 28 *s*, 81 *s*, 91, 99, 119, 285. See also *G*
speed, 253 (C)
theories postulating, 251-7
varieties of, 51
Factor theory of inheritance, 3-2
" Faculties," 18-2 (A) *s*, 193
and overlap, 52-7
" Faculty " of attention, 125-3 (A)
theory, 251 (A)
validity of, 32 (C)
Failure and *g*, 33 *s*
cognitive, 57, 113, 263-8
of control, 248-4

Familial inheritance, 107 (*ii*)
Fatigue, 84, 114 (**D**) *s*, 145 *s*, 191 *s*, 237, 263-**8**
  chronic liability to, 88-**5** (**B**)
  general and specific, 87-**3**
  muscular, 38
  subjective and objective, 85-**2**
  transference of, 88-**5** (**B**)
Fatiguability, 104-**3** *s*
Fear, 9 (**B**), 64, 73-**7** *s*, 143-**7**
Feeble-mindedness, 103, 107-**8**
Feeling, 8-**2** *s*
Fiat, volitional, 142-**5**, 145, 208
Fiction, 214
Finger movements, 49
Fluctuations in cognitive efficiency. See *Oscillation*
Fluency of association, 21
Focus of awareness, 60, 66 (**B**), 117 (**C**)
  of eye, 38 (**A**)
Force, gravitational, 2, 178
  physical, 176 (**B**)
Foreign language, 171 (**B**)
Foresight, 215 (**C**)
Formal training, 300-3
Free eduction, formation of concepts by, 206 (**C**)
Function of consciousness, 235 *n*
Fundamental nature of laws, 5-**4** *s*
  principles in science 249-**6** *s*
Fusion, formation of concepts by, 205 (**B**)

G

G, 28-**6**, 33, 54-**2**, 80, 101, 113 (**A**) *s*, 125-**3** (**A**), 131-**1**, 183, 205, 217, 223 *s*, 248-**5** *s*, 261 *s*, 270-**10**, 275, 285, 306, 314-**6**
  and age, 102-**2**
  and analogy of electrical energy, 55
  and brain, 35
  and brain injury, 110-**14**
  and car driving. See *Car driving*
  and chess, 112-**1**
  and cognitive competition, 62 (**B**) *s*
  and cognitive improvement, 37
  and death, 256 *n*
  and deterioration of brain tissue, 36-**4**
  and eduction, 183-**2**
  and general ability, 34-**2**
  and ill health, 110-**15**
  and Latin, 43-**2** (**A**), 309
  and maximum efficiency, 57
  and monarchic views, 31-**10** (**A**)
  and parental inheritance, 107-**8**
  and psychotherapeutic treatment, 36-**4**
  and quantitative determinants, 116-**2**
  and race, 105-**5**
  complexity of, 227-**6**
  conation, volition and, 228 (**A**)
  connection of thyroxine with, 36-**4**
  controversy over, 246
  correlation due to, 43-**2** (**A**), 285, 314-**6**
  growth of, 103
  indeterminacy of, 228 (**B**)
  individual differences in, 31 (**B**), 183-**1**
  ineducability of, 36-**4**, 310
  inhibition of, 36-**4**
  inheritance of, 36-**4**, 105 (**B**) *s*
  maximum development of, 103
  measurement of, 183-**2**
  nature of, 34-**3** *s*, 183
  non-fatiguability of, 38 (**A**)
  physiological aspect of, 35 (**C**), 227-**6**
  poverty of, 34-**3** (**B**)
  psychological aspect of, 227-**6**
  quantitative differences in, 310
  saturations with, 183-**1** *s*, 229
  sex differences in, 108-**11**
G : *s* ratio, 30-**9** (**A**), 55, 230 *n*
G, telederigibility of, 117 (**C**)
  universality of, 27 *s*, 32 *s*, 52
  variable amount of, 55
Games, compulsory, 300-**4**
General ability, 18. See also *G*
  determinants of ability, 120
  factor. See *Factor, general*
  fatigue, 87-**3**
  ideas, 205 (**B**)
Genes, 252 (**B**)
Genesis of knowledge, 181 (**B**), 232-**8**
Genius, 14, 18, 34-**2**
  sex tendencies towards, 108-**11**

Geometry, 109-12, 297-9 *s*
Gestalt psychology, 245-1 *s*
Glands, endocrine, 16. See also *Thyroxine*
Glandular constitution, inheritance of, 36-4
Glucose, brain supply of, 34-3 (**A**)
Goal-seeking, 10
God, as First Cause, 178 (**C**)
  one concept of, 207
Golf, 113 *n*
Gratitude, 9 (**B**)
Gravity, 2 *s*, 178
Greyness, 137 (**A**)
Grief, 77-1
Group factors, 50-6, 56-3, 228 (**B**), 252 (**B**)
Growth of knowledge, 121, 131-1, 182, 241-13, 250 (**B**)
  of *g*, 102 (**A**)
Gustatory sensations, 138

H

Habit, 29-8 (**A**) *s*, 55, 63-3, 69-3 *s*, 148-3, 177, 208, 263-8
Hand-washing mania, 75 (**B**)
Happiness, 9 (**B**)
Health, 109 (**D**), 119-4, 141, 253 (**C**)
Heat, 138
Hedonic feelings, 140-3 *s*
Hens, 159 (*I*)
Heredity, 105 (**B**), 119-4
"High level" activities, 73-7, 79 (**B**), 104-3
  nature of *s* in, 40-7
  competition, 62 (**B**)
Hormic control, 237 *n*
  psychology, 245-1, 248-5
House of Commons, 266
Humour, 82-5, 239-11
Hypnosis, 134-4
Hypotheses of ability, 54-1
  nature of scientific, 1
Hysteria, 81
  and thought, 64

I

Ideal relations, 295
Ideals, 303, 308 *s*
Ideas, 41, 104-3, 170-4, 186, 202 *s*, 235
Idiocy, 14, 34-2
  sex tendencies towards, 108-11
Ignorance, 131-1, 146-1, 167-1, 182
Ill-health, 110-15
Illusion, bird-rabbit, 153
  Müller-Lyer, 154 (**D**)
  visual, 78
Imageless awareness, 205 (**B**)
Imagery, 205 (**B**)
  overlap in, 50 (*V*)
Images, 202
Imagination, 19, 109, 175-6, 193, 210 *s*
  auditory, 19
  cognitive nature of, 217
  practical importance of, 215
  visual, 19
Imbecility, 35 (**D**)
"Immediate" awareness, 144-8
Immediate memory, 314-6
Implicit relation eduction, 162, 166 (**C**), 240
Impossible eductions, 218
Impotence, 142
Improvement of ability, 36-4 *s*
  reciprocal, 300-3
Impulse, neural. See *Neural impulse*
Inanimate matter, 177 *s*
Incentives, 88-5 (**A**)
  and retentivity, 315
Indeterminacy of *g*, 228 (**B**)
Individual differences in ability, 14, 101
  in *g*, 31 (**B**), 183-1
  in *o*, 94
  in *p*, 81
  in *w*, 99-6
Induction of neural impulses, 119
Inertia, 77, 114 (**C**), 117 (**B**), 191. See also *Perseveration*
Ineducability of *g*, 36-4, 310
Infantile behaviour of cretins, 34-3 (**B**)
Infinite, concept of the, 207
Influence, personal, 82-5
Information, recollection of, 210
Inheritance, 3-2 *s*, 16, 95, 106-7, 310
  of *g*, 36-4
Inherited genes, 252 (**B**)
Inhibition of cognition, 64, 148, 212-2, 237, 272

Inhibition of conative control, 118 (E)
of *g*, 36-4
Initiation of activity, 98
Injections, 35 *s*
Injure to brain, effects of, 36-4, 110-14
Innate activities, 29-8 (B), 33, 55, 63-3, 68-1, 71-5
propensities, 248-5
Insects, 160 (C)
Insight, 49, 177, 181, 250 (B)
Instinct, 257
Instinctive tendencies, 9 (B)
Intellect, 19, 204, 213-3, 257
and intelligence, 17-1
" Intelligence," 23-5, 31-10 (A), 37, 183, 257
alleged varieties of, 251 (A)
and abstract ideas, 18
and eduction, 183-5
and intellect, 17-1
disagreement over definition of, 18
Hazlitt's view of, 237
tests, 183-2, 238
" Intelligent " behaviour, 246
Intercolumnar correlations, 223, 225-3
Inter-correlations, 283-4 *s*
Intercourse, mediumistic, 182 *n*
social, 49 (*II*)
Interest in religion, 83-5
Internal organs and sensations, 138
Intensity of cognition, 97, 115 (F), 137-1 *s*, 151 (C), 195-1, 205, 212, 296-5
Intensiveness of cognition, 96-2
Introspection, 122, 134-4 *s*, 164, 196
Introspective psychology, 245-1 *s*
Introversion, 20 (B), 82
Intuition, 20 (B)
Isochronic neurones, 119 *n*
Isolated events. See *Facilitation*
Investigation, scientific, 133-3
Investigations with dice, 252 *n*

J

Jays, 159 (*II*)
Jews, 106
Joints, 138
Joy, 9 (B)
Judgment, 204 *s*
mathematical and selective, 284

K

Kinæsthetic sensations, 138
Knowing, 8-2, 140-2
Knowledge, 6, 121 *s*, 257
birth of, 181 (B)
growth of, 131-1, 182
originality of, 233
problems of, 193

L

Lag, 78
Language, 19, 259-5
acquisition of, 41, 171 (B)
Latin, 43, 187-4, 270, 299-2 *s*
and *g*, 30-9 (A) *s*
overlap in, 29-8 (C)
Law of apprehension of experience, 136, 190
of association, 72, 191
of basic conditions, 102, 191
of clearness variation, 123, 192
of cognition, psycho-physical, 135, 190
noëgenetic, 136, 146, 167, 190
of cognitive variability, 91, 191
of constancy of output, 67, 191
of control, 100, 191
of correlate eduction, 167, 191
of facilitation of isolated events, 68, 191
of paired events, 72, 191
of fatigue, 84, 191
of inertia, 77, 191
of *o*, 91, 191
of *p*, 77, 191
of relation eduction, 146-1
of reproduction, 124, 192
of retentivity, 68, 191
of *w*, 100, 191
Laws of cognition, 129-5, 167-1, 190
quantitative, 58, 67 *s*, 77, 84, 91, 100 *s*, 191
complementary, 4-3
criteria of acceptable, 5-4
of motion, 136
nature of scientific, 1
psychological, 259-5
unequivocal expression of, 5-4 *s*

Learning, 69-3, 73-7, 259-5
effects, diffusion of, 299 *s*
facility of, 246
reciprocal improvement in, 300-3
Leg muscles, 38 (B)
Liaison between two factors and noëgenetic theories, 183, 190
Limitations of experience, 180-7, 202-4, 213-3
Linguistic ability, 40-7, 51 *s*, 109 *s*, 262
" faculty," 22-3
overlap, 50 (*IV*)
Literary interpretation, 284
metaphors, 218
Lived experience, 134-4 *s*, 168-3
Localisation of experience, 139 (C)
temporal, 210
Logic, 109
and " intelligence," 18
Logical overlap, 50 (*IV*), 251 (A)
Longing, 10-3
" Low level " activities, 73-7, 77 (A)
and age, 104-3
and *s*, 37-6
Love, 9 (B)
Lunacy, 267

M

Magic, 76
Maladjustment, temperamental, 261-7
Mammals, 157-7 (A)
Mania, handwashing, 75 (B)
Manipulative ability, 263-8
Manual activities, overlap in, 49
Manual skill, 49, 304 (B)
Mathematical analysis of data, 3-2, 27 *s*, 260-6, 276 *s*
of mental " types," 21
association. See *Correlation*
investigation of overlap, 43-2, 288-7 *s*
judgment, 284
Matter, inanimate, 177 *s*
Maturity, 104-3, 109-13, 253 (C)
Meaning, 73-7, 149-4, 161-8, 181, 195-1
acceptable view of, 200 (C)
emotional, 64
nuances in, 188
problem of, 198-3 (A)
traditional view of, 198-3 (B)
Measurement of *g*, 183-2, 290 (C) *s*
Mechanical ability, 46 (B), 52-7, 109-12, 262
" faculty," 53
" intelligence," 251 (A)
overlap, 46 (B) *s*, 251 (A)
Medical profession, certification of lunatics by, 267
Mediterranean races, 106
Mediumistic intercourse, 182 *n*
Melancholia, 81
Melody, relations and, 156-6
Memory, 19, 96-1 *s*, 164 (B), 177, 193, 198-3 (A), 210, 259-5, 304 (B), 314-6
alleged limitations of, 213-3
and constant output, 62 (C)
and overlap, 50 (*IV*)
auditory, 19
rote, 165
visual, 19
Mendelian unit, recessive, 107-8
Mental activity, initiation of, 98
arithmetic, 49 (*III*)
deficiency, 34-3 (B)
discipline, 300-3
effort, 10 (D). See also *Conation*
energy, 228 (A)
powers, discreteness of, 18-2
processes, 7
complex products of basic, 19
ratio, 314-6
set, 97-4, 100 *n*, 102, 115 (F), 241-14
states, abnormal, 8
" types," 18-2, 20 (B), 23-5
Metaphors, literary, 218
Method of procedure, 104-3
Mimicry, 73-7
Minus quantities, 173 (B)
Mirror drawing, 70, 305
Monarchic and oligarchic views contrasted, 20 (B)
theory, 232, 251 (A)
and *g*, 31-10 (A)
of ability, 17-1, 23-5
validity of, 32
Mongolian races, 106
Monotony, 87-4

Mood, concept of, 265 *n*
Motion, Newton's laws of, 136
Motive, 97-3. See also *Persis ence of motive*
Motor factors, specific, 253 (C)
Movement, 19
  of fingers, 49
  in and out of awareness, 92-3
  sensations of, 138
Müller-Lyer illusion, 154 (D) *s*, 249 (A)
Multi-focal theory of ability, 23-5 *s*, 251 (A)
Multiplication, 49-*III s*, 84
Muscles, 38, 86, 138
Muscular activities, 104-3
  fatigue, 38 (A) *s*
  organs, 37-5
Music, 156-6, 168-2, 196
Musical ability, 18, 108, 257
    g and *s* in, 31
    overlap in, 50 (*IV*)
  transposition, 156-6, 168 *n*
Mystical dreaming, 20 (B)
  experience, 182 *n*

N

National Institute of Industrial Psychology, 261 *s*
Nature of ability, experimental investigation of, 23
    two-fold, 52
  g, 34-3 *s*, 183
  s, 39 (C)
  scientific laws and hypotheses, 1
  sensation, dynamic, 195-1
Necessity for experiment, 25
  research, 102
  statistical treatment, 26-3
Negative quantities, 173 (D)
Negroes, 106
Nerve cells. See *Neurones*
Nervous breakdown, 158 (*II*)
  system, 16
Nest building, 71-5
Neural activity, 118-3 (A), 132, 135
  bases of *s*, 37-5
  conduction units, 251 (A)
  impulse, 38 (B), 118-3 (B)
  retentivity, 104-3, 118-3 (B), 127
Neurones, 86, 112-1, 127, 144-8, 252 (B)
  connector and receptor, 37-5 *s*
  effector, 37-5 *s* 43
  isochronic, 119 *n*
  stimulation by alcohol, 214 (B)
Noëgenesis, 182 (C) *s*, 232 (B) *s*, 256 *s*, 299-1
Noëgenetic laws of cognition, 136, 146, 167, 190, 193
  processes, 204
  supplementation of experience, 178, 195-1, 202
Noësis, 180-8 (A), 232-8
Non-cretinous imbecility, 35 (D)
Non-fatiguability of *g*, 38 (A)
Non-focal theory of ability, 23-5, 226-4, 251 (A)
Nordic races, 106
Noise, 138
Nose, 138
Noticing, 140-2
Nowness, notion of, 139 (D), 211
Nuances in meaning, 188
Numbers, 150
  recollection of, 165

O

O, 91 *s*, 119-5, 126, 191, 243, 263-8
  and age, 105-4
  and parental inheritance, 108-10
  and racial inheritance, 106-7
  importance of, 94-6
  sex differences in, 108-11
  time aspect of, 94
Objective fatigue, 85-2, 88-5 (A)
  " type," 20 (B), 82
Observation, 3-2, 140-2, 259-5
  remote and immediate, 4
  statistical, 82
  statistical treatment of, 223
Occupational misfits, 261-7
Olfactory acuity, 106-6
  sensations, 138
Oligarchic and monarchic views of ability contrasted, 20 (B)
  theories of ability, 18-2, 23-5, 82, 232, 251 (A)
    validity of, 32 (C)
Opinion, 207-2
Optic nerve, 132

Orectic elements in mental "types," 21
Orexis, 12 (**B**), 73-7 *s*, 77-1, 100-7, 118 (**E**), 141, 164, 217, 248 *s*, 308 *s*
  and cognition, 10-3
Organ pipe, note of, 137 (**A**)
Organs, effector, 37-5 *s*
  muscular and sensory, 37-5
  of balance, 39 (**C**)
  receptor, 37-5, 42
Orientation, sensations of, 138
Originality, 82-5
  of knowledge, 233
Oscillation. See *o*.
Output. See *Constancy of cognitive output*
  curve of, 94
Overlap, 29-8 (**C**), 42, 56-3, 227, 232, 251 (**A**) *s*, 263-8, 290, 307, 314
  and "faculties," 52-7
  correlation due to, 44 (**B**), 47. 290
  detection of, 43-2
  examples of, 46 (**B**)
  in arithmetical abilities, 49 (*III*)
  in constructive abilities, 46 (**B**)
  in imagery, 50 (*V*)
  in linguistic activities, 50 (*IV*)
  in logical activities, 50 (*V*)
  in manual abilities, 49
  in mechanical abilities, 46 (**B**)
  in memorization, 50 (*IV*)
  in musical abilities, 50 (*V*)
  in non-verbal symbols, 50 (*IV*)
  in reaction times, 50 (*V*)
  in routine activities, 49
  in sensory memories, 50 (*IV*), 313-5
  in social activities, 49 (*II*)
  in verbal activities, 50 (*IV*), 253 (**C**)
  physiological aspect of, 44 (**B**)
  theory of, 44-3 *s*
  unimportant, 46-5
Oxygen, brain supply of, 34-3 (**A**)

P

P, 77 *s*, 81, 98-5, 114 (**C**), 119-5, 126 *s*, 245 *s*, 191, 211, 236 *s*, 264
  absence of, 83
  and age, 105-4
  and parental inheritance, 108-10
  and racial inheritance, 106-7
  and "types," 81-4
  sex differences in, 108-11
Pain, 138, 140-3, 233
Paired events. See *Facilitation*
Palate, 138
Paradox, Hume's, 175-6
Paralysis, 110-14
Parental inheritance, 95, 107
Parliamentary election, method of, 266
Partial identity of *s*'s. See *Overlap*
Past experience, revivification of, 127
Pastness, notion of. 211
  taint of, 128 (*II*), 211
Past occurrences, effect of, 7
Pathology, 66 (**B**), 81
Pathological imagination, 214 (**B**)
  symbolism, 75 (**B**)
Peerage, 267
Perception, 9, 19, 77-2, 136, 175-6, 193 *s*, 204, 208, 212-2
  alleged limitations of, 213-3
  and correlate eduction, 198-3
  and relation eduction, 197
  and sensory apprehension, 195-1
  subjective effect of, 20 (**B**)
Percepts, 295 *s*
Perseverance, 100, 109, 310
Perseveration, 68. See also *P*
Persistence of motive, 99-6
Personal conduct, 49 (*II*)
  influence on others, 82-5
Philosophy, 133-3, 140-3
Physical disabilities, 227
  force, 176 (**B**)
  maturity, 109-13
  prerequisites of cognition, 132
Physiological aspect of ability, 54-1
  of *g*, 35 (**C**)
  of overlap, 44 (**B**)
  bases of *g*, 227-6
  bases of *s*, 39 (**C**)
  prerequisites of cognition, 132
  processes, 16
  psychology, Russian School of, 72-6
  traits, 287
Pictures, 151 (**C**)

Pitch, musical. See *Relations*
Play, 213 (**A**)
Pleasure, 9 (**B**), 140-**3**
Political fitness, 266 (**C**) *s*
  reform, 217, 265 *n s*
Politics, 264 *s*
Popular press, 271
Posture, sensations of, 138
Poverty in *g*, 34-**3** (**B**)
Practice, 68-**1**
  and theory, divorce between in psychology, 258-**3**
  and training contrasted, 301 *s*
Precognition, 182 *n*
Preference, 251 (**A**)
Pre-history of new cognitions, 131
Press, the popular, 271
Pressure, 138
Pretence, 213 (**A**)
Primitive races, 106-**6**
Principles in cognition, 249-**6**
  in psychology, 260-**6**
Problems, arithmetical, 49 (*III*)
  of ability, 14, 57
    methods of solving, 23
  of knowledge, 121, 193
  of meaning, 198-**3** (**A**)
  of political representation, 264-**9**
Products of basic processes, 19
Pronunciation, 69-**2**, 151
Proof of two factors theory, 224
Propaganda, 64, 272
Propensities, innate, 248-**5**
Proton, 230
Psychoanalysis, 75 (**B**), 245-**1**, 248-**4**
Psychology, Schools of, 245 *s*
Psychophysical law of cognition, 135, 190
Psychotherapeutic treatment, 75 (**B**)
  and *g*, 36-**4**
Psychotherapy, 74-**9** *s*, 105-**4**
Public Schools, 300-**4**
Pure-mindedness, 82-**5**
Purpose, 237, 251
Purposive activity, 142
Purposivism, 245-**1**, 248-**5**

Q

Qualitative differences in ability, 14
Quality of brain tissue, inheritance of, 36-**4**
  of cognition, 124-**2**, 137-**1**, 151 (**C**), 195-**1**, 243-**16**
Quantitative aspects of ability, 20 (**B**)
  determinants, 58 *s*, 102, 112-**2**, 115-**3**, 121, 126, 145, 148, 162, 193, 235 *s*, 241 (**C**), 243-**16**, 245 *s*, 256, 260 (**B**), 263-**8**, 275
    and age, 105-**4**
    and *g*, 116-**2**
    and ill health, 110-**15**
    and parental inheritance, 108-**10**
    and racial inheritance, 106-**7**
    and *s*, 118-**3**
  differences in ability, 14
    in *g*, 310
  laws of cognition, 58, 67 *s*, 72, 77, 84, 91, 100 *s*, 191
  principles, 135 *n*
Quantities, negative, 173 (**D**)
Quantity of energy, 228 (**A**)
Quickness of apprehension, 82-**5**
  of response, 21

R

r, 279-**2**
Race, 253 (**C**)
Racial differences in *g*, 105-**5**
  inheritance, 95
    and *g*, 105-**5**
    and *s*, 106-**6**
Rage, 143-**7**
Rate of working, 84
Rats, 157-**7** (**A**)
Reaction times, overlap in, 50 (*V*)
Realisation of the absent, 215 (**C**)
Reasoning, 193, 204, 209
  power in children, 108-**11**
Recall. See *Memory*
Receptor neurones, 37-**5** *s*
  organs, 37-**5** *s*, 104-**3**
Recessive Mendelian unit, 107-**8**
Reciprocal improvement in learning, 300-**3**
Recognition, 128 (*II*), 210 *s*
  of words, nature of *s* in, 41
Recollection. See *Memory*
Reduction of synaptic resistance, 119

Reform, political, 217, 265 *n s*
Regret, 9 (**B**)
Relational systems, 175, 200 (**C**) *s*, 214 (**B**) *s*, 238
  thinking, 306
Relation eduction, 146 *s*, 168-**2**, 174-**5**, 179 (**D**), 184, 190, 194, 205, 208, 211, 228, 233, 237, 239-**12**, 249 (**A**) *s*, 263-**8**, 275, 305 *s*
  between relations, 238
  implicit and explicit, 148-**3**, 162, 166 (**C**)
  in animals, 157-**7** *s*
  in perception, 197
Relations, 35 (**E**), 47, 167-**1** *s*
  additive, 216
  and melody, 156-**6**
  causal, 49, 176 (**B**), 296-**5**
  eduction of correlates from, 175
  grammatical, 151, 171 (**B**), 188
  ideal, 295
  in animal psychology, 157-**7** *s*
  in child psychology, 172 (**C**)
  incongruous 239-**11**
  of adequate ground, 207
  of attribution, 208, 295-**1** *s*
  of conjunction, 297-**9**
  of constitution, 297-**7**
  of difference, 168-**2**, 173, 197, 212-**2**, 238 *s*
  of equivalence, 173 (**D**)
  of evidence, 209, 298-**10**
  of extent, 216
  of half to whole, 238
  of identity, 189, 212-**2**, 296-**2**
  of juxtaposition, 238
  of likeness. See *Of similarity*
  of mother to baby, 214
  of objectivity, 296-**6**
  of oppositeness, 170-**4**, 179 (**D**), 207
  of root to square, 173, 238
  of repetition, 175
  of sequence, 177
  of similarity, 147-**2** *s*, 206, 212-**2**, 297-**8**
  of square to root, 240
  of succession, 211
  of synonymity, 239-**11**
  of unlikeness, 147-**2** *s*, 206
  of verticality, 180-**8** (**A**)
  of visual intensity, 176, 208
  pitch, 157, 168-**2**, 196
  psychological, 296-**6**
  quantitative, 203
  rational and real, 295
  relevance of, 236-**10**
  spacial, 48, 109-**12**, 147-**2** *s*, 171, 188, 200 (**C**), 208, 240, 249 (**A**), 263-**8**, 296-**4**, 306
  subtle, 160
  suggestion by means of, 163
  temporal, 188, 263-**8**, 296-**3**
Relative importance of *g* and *s*, 30-**9** (**A**), 230 *n*
Religion, affective elements in, 64
  interest in, 82-**5**
Religious apologetics, 256
Remembering. See *Memory*
Remorse, 9 (**B**)
Remuneration and *g*, 273-**12**
Repetition, 68-**1**, 73-**7**
Reproduction, 124, 131-**1**, 148-**3**, 171, 175-**6**, 182 (**D**) *s*, 192, 195-**1**, 199, 203, 208 *s*, 212-**2** *s*, 230, 272, 306. See also *Association*
  double, 217
Research, necessity for, 102
Resistance, synaptic, 119
Resolution. See *Volition*
Response, quickness of, 21
Rest, 87
Restricted scope of genius, 18
Retardation of *g*-growth, 103
Retentivity, 68, 77, 104-**3**, 110-**14**, 126-**4** (**A**), 191, 211, 236, 306
  in the special senses, 312 *s*
Retina, 132
Retinal fatigue, 38 (**A**)
Retrocognition, 182 *n*
Revelation, Divine, 182 *n*
Reverence, 9 (**B**)
Reversible perspective, 92-**3**, 154 *n*
Revivification of past experience, 127
Rheobase, 119 *n*
Road safety, 263-**8**
Roots, mathematical, 173, 238, 240
Rote memory, 165
Routine manual activities, overlap in, 49

S
S, 72, 80, 101, 113 (**A**) *s*, 119-4 *s*, 125-**3** (**A**), 131-**1**, 186, 223, 229, 232, 251 (**A**) *s*, 261 *s*, 270-**10**, 275, 285, 314
and age, 104-**3**
and brain injury, 110-**14**
and chess, 112-**1**
and ill health, 110-**15**
and quantitative determinants, 118-**3**
and race, 106-**6**
sex differences in, 109-**12**
Salivation, 73-**7**
Saturations with *g*, 183-**1**, 185, 229
Sampling and two factors theories compared, 293 (**D**)
error, 229
theory, 252 (**B**)
Scholastic disabilities, 227
Schools of psychology, 245-**1**
Public, 300-**4**
Scientific concepts, 206 (**C**)
investigation, 133-**3**
principles, 258-**4**
Selective judgment, 284
thinking, 306
Self, The. See *Ego*
activity, 142
awareness, 177 *s*
control, 105-**4**
consciousness, 140-**2**, 145
criticism, 109, 303
Semi-circular canals, 138
Senility, 102-**2**
Sensation, characters and varieties of, 137-**1**
dynamic nature of, 195-**1**
Sense impressions, 104-**3**
of humour, 82-**5**
organs, 137-**1**
Sensory apprehension and perception, 195-**1**
experience, 137-**1** *s*
factors, specific, 253 (**C**)
retentivity, 312 *s*
Sentience. See *Lived experience*
Set. See *Mental set*
Sex, 95, 108 (**C**), 119-**4**, 253 (**C**)
differences and *s*, 109-**12**
Sexual maturity, 109-**13**
Sheep dogs, 157 *n*
Similarity, association by, 163
Simultaneity, association by, 163
Simple emotions, 143-**7**
Skill, acquisition of, 259-**5** *s*
Skilled activities, 70-**4**
Skin, 138
Sleep, 97-**3**, 111
Smell, 138
Sociability, 82-**5**
Social discontent, 262
" intelligence," 251 (**A**)
level, 95
Soft palate, 138
Space, 178
Spacial character of cognition, 137-**1** *s*, 151 (**C**), 195-**1**
contiguity, 163
Span, 66-**6** (**A**)
Special abilities, 246, 251 (**A**)
Specific factors. See *S*
fatigue, 87-**3**
Spectrum, 137 (**A**)
Speed factor, 253 (**C**)
Spelling, 284
Sport, 266
Statistical analysis, 226-**4**
methods, 122, 276 *s*
nature of two factors theory, 222
observations, 82
Strain, 142
Stupidity, 154 (**D**), 249 (**A**)
Subconsciousness, 125, 196, 212
Subjective fatigue, 85-**2**
" type," 20, 82
Success. See also *Cognitive success*
and *o*, 94
vocational, 95, 261-**7**
Suggestibility, 109
Suggestion, 76
by means of relations, 163
Supplementation, noëgenetic, 178, 195-**1**, 202
Surgency, 20, 82
Syllogism, 209
Symbolism in dreams, 214 (**B**)
pathological, 75 (**B**)
Symbols, visual, 149-**4** (**A**)
Sympathy, 217
Synapse, 118-**3** (**B**)
Syneidetic process, 234

Synonyms, 166, 171
Systems of relations. See *Relational systems*

T

Tactile discrimination, 109-12
  sensations, 138
Taint inherited, 107-8
Talent, 257
  and reward, 273-12
Taste, 138
Technique, acquisition of, 307
Teledirigibility of *g*, 117 (C)
Telepathy, 182 *n*
Temper, 264
Temperament, 83, 108-10, 257, 273-12
  artistic, 20 (B)
Temperamental maladjustment, 261-7
Temporal character of cognition, 137-1 *s*, 151 (C), 195-1, 211
  contiguity, 163
Tendencies, instinctive, 9 (B)
Tendons, 138
Tension, 142
Tests, battery of, 283-4 *s*
  for political candidates, 268 (D)
  of "intelligence," 183-2
  mental, 238
Tetrad differences, 223, 282 *s*
Theories of ability, 31-10
  postulating factors, 251-7
Theory and practice, divorce between, 258-3
  of inheritance, 3-2
  of overlap, 44-3 *s*
Thought, 9
  absence of, in Behavourists, 235 *n*
  abstract, 40-7
  and emotion, 63-4 *s*
  selective and relational, 306
  unbiassed, 64
Threshold of awareness, 127, 143
Trustworthiness, 100
Thyroxine, 34-3 (B)
Time aspect of *o*, 94
  localisation of experience in, 210
  waking at pre-selected, 97-3
Tone, 138
Tongue, 138
Toxins, 86, 118-3 (A)
  effects of, 36-4
Traditional views in psychology, 193
Training, formal, 300-3
  transfer of, 300-3
  and practice contrasted, 301 *s*
Transcendental correlates, 174-5, 233
Transference of fatigue, 88-5 (B)
  of training, 300-3
Transposition. See *Music*
Treatment, psychotherapeutic, 75 (B)
Two factors theory, 23 *s*, 119-5, 183, 190, 222, 245, 252 (B), 275, 299-1
  alternative proofs of, 224
Two factors and other theories, 31-10
  and sampling theories compared, 293 (D)
Two factors theory, criticisms of, 223 *s*
  eclectic nature of, 32 (C)
  statistical nature of, 222
  validity of, 27-5, 224
"Type" and "faculty" views contrasted, 20 (B)
"Types" and *p*, 81-4
  mental, 18-2 *s*
  inadequacy of views, 21
Types of conscious experience, 8-2
Typographical errors, 60, 73-7, 150, 242

U

Unbiassed thinking, 64
Uncongenial activities, 87-4, 97-3, 177
Unequivocal expression of laws, 5-4 *s*
  principles, 260-6
Uni-focal views of ability, 23-5 *s*, 251 (A)
Unit effort of will, 228 (A)
Unity of conscious experience, 12-5, 197
Universal application of laws, 5-4 *s*
  principles, 260-6
  suffrage, 270-10

Universality of *g*, 32 *s*, 52
Unpleasure, 9 (**B**), 140-**3**
Up-and-down movements of ability, 92-**2**
Unconscious control of cognition, 97-**3**
disposition, 97-**4**
processes, 7
Unconsciousness, 34-**3** (**A**), 179 (**D**)

V

Validity of theories of ability, 32 *s*
of two factors theory, 27-**5**, 224
Variations in capacity, 57, 70-**4**. See also *o*
Verbal ability, 109
expression, 41
Verbalization, 204-**1** *s*
Verbal memory, overlap in, 50 (*IV*)
overlap, 251 (**A**) *s*
Verbosity, 109
Vicarious functioning of brain cells, 41
Visceral sensations, 138 *s*
Visual acuity, 106-**6**
cognition, extent of, 59
illusion, 78
imagination and memory, 19
nerves, 42
sensations, 138
spectrum, 137 (**A**)
symbols, 149-**4** (**A**)
Vocational guidance, 261 *s*, 268 (**D**)
success and *o*, 95
Volition, 10 (**D**) *s*, 65-**5**, 77-**1**, 85-**2** *s*, 97-**3** *s*, 105-**4**, 115 (**F**) *s*, 142-**5** *s*, 177, 207-**2**, 228 (**A**), 242, 248, 257, 296
and conation distinguished, 10 (**D**)
function of, 98
Volitional competition, 65-**5**
control. See *Control of cognition*
Voluntary improvement of ability, 36-**4**

W

W, 99-**6** *s*, 119-**5**, 191
and age, 105-**4**
and parental inheritance, 108-**10**
and racial inheritance, 106-**7**
sex differences in, 108-**11**
Wages and *g*, 273-**12**
Waking at pre-selected time, 97-**3**
Washing mania, 75 (**B**)
Wasp, behaviour of, 160 (**C**)
W.E.A., xiii, 270-**10**
Whiteness, 137 (**A**)
Willing, 8-**2**. See also *Volition*
and striving distinguished, 8-**2**, 10 (**D**)
Workers' Educational Association. See *W.E.A.*
Working, rate of, 84
Words, 149-**4** (**B**)
Word-recognition, nature of *s* in, 41
Writing, automatic, 66 (**B**)
nature of *s* in, 41

Z

Zero, notion of, 173 (**D**)

PRINTED IN GREAT BRITAIN
BY ROBERT MACLEHOSE AND CO. LTD.
THE UNIVERSITY PRESS, GLASGOW