

THE
PSYCHOLOGY
OF
EFFICIENT
THINKING

by Zbigniew Pietrasiński



PERGAMON PRESS

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by
ZBIGNIEW PIETRASIŃSKI

translated by BOGUSŁAW JANKOWSKI



THE QUEEN'S AWARD
TO INDUSTRY 1966

PERGAMON PRESS
OXFORD ● LONDON ● EDINBURGH ● NEW YORK
TORONTO ● SYDNEY ● PARIS ● BRAUNSCHWEIG

WIEDZA Powszechna
WARSAW

Pergamon Press Ltd., Headington Hill Hall, Oxford 4 & 5 Fitzroy Square, London W.1

Pergamon Press (Scotland) Ltd., 2 & 3 Teviot Place, Edinburgh 1
Pergamon Press Inc., 44-01 21st Street, Long Island City, New York 11101

Pergamon of Canada Ltd., 207 Queen's Quay West, Toronto 1

Pergamon Press (Aust.) Pty. Ltd., 19a Boundary Street, Rushcutters Bay, NSW 2011, Australia

Pergamon Press S.A.R.L., 24 rue des Écoles, Paris 5^e
Vieweg & Sohn GmbH, Burgplatz 1, Braunschweig

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Wiedza Powszechna

First English edition 1969

This book is a translation of **Psychologia Sprawnego Myślenia**
published by Wiedza Powszechna, Warsaw, in 1960

Library of Congress Catalog Card No. 68-18526

Printed in Poland
08 012544 1

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INTRODUCTION

The following consideration explains in part the reason for writing this book. Regrettably, very little has been done to put to practical use the expanding science of man and his mental functions. This is particularly striking in the field of education and upbringing. In fact, scientists seem to be far more concerned with making the best of recent advances in the treatment of their particular fields of work than is the case with either teachers or parents. But are we justified in comparing the working techniques of a teacher with those of the scientist? Can it be that the teacher is assisted by the native intelligence of the organism, while the scientist has no such help? Recent advances in psychology seem to indicate that the real function of nurture (that is, all sorts of educational influences) lies in the formation of the mental traits of man rather than in a hothouse cultivation of faculties determined by natural growth. If this is so, should we not assume that by this stress on the need for an improvement of the techniques of teaching mental skills and for an appropriate allocation of resources, new and vast prospects of development would arise for this vital asset of the human race—the number and quality of eminent brains and their competence in creative work?

Efficiency of performance in a job is largely determined by the preparatory mental effort expended in the initial stages of the task, thereby illustrating the practical significance of training in mental skills. An essential condition of any country's economic and social progress lies in the rise in the general intellectual level of the community and the attaching of high social prestige to intellectual ability. Both the individual and society will benefit from this: there is no question whatever that, other things being equal, greater efficiency

in the thought of an individual and broader knowledge, will enable him to master new skills and vocations more readily, and his mental productivity or even his bodily competence will be higher.

The present volume is intended to provide both young people and adults with information concerning:

- (1) intellectual abilities,*
- (2) psychological principles of thinking which might be helpful in the solution of more complex problems encountered in the vocational field or in everyday life,*
- (3) ways and means of increasing the efficiency of thought.*

These topics are discussed in the three parts of the book: the first of these deals with the nature of intellect, with special reference to mental abilities and intelligence, and with the general field of mental development; the second with the application of intellect in such spheres as problem solving, technical invention, and general creativity; the third with the training of the intellect, both at school and by individual effort.

PART ONE — THE NATURE OF INTELLECT

The decisive factor—not only in choosing a vocation but, what is far more important, in focusing the yearnings, dreams, and strivings of man, decisive for the general course of his life, and the level he may reach—is “that which impresses him”, that which impresses him most strongly.

A. B. DOBROWOLSKI

THE time we live in is marked by a universal interest in the results achieved by the human body—for example, in sport. It would seem strange, indeed, if a nation intent upon its advance had less need for a thorough knowledge of the intellect, especially as far as it affects the rate and cost of economic progress, and, moreover, defines the level of national culture. In this book we undertake to investigate some aspects of the intellect which—together with basic elements of knowledge—determine the efficiency of our actions, and yet have aroused surprisingly little interest so far. In this connection the concept of abilities seems particularly revealing.

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CHAPTER I

THE INTELLECTUAL ABILITIES

THE CONCEPT OF ABILITY

Since time immemorial people have been aware of the striking individual differences in the comprehension, speed, accuracy, and ingenuity of the human mind. Similar divergencies were found in the abilities to draw, to play instruments, in manual dexterity and so forth. This dissimilarity was commonly designated by the term "ability", long before the first attempt was made to investigate this phenomenon.

The term ability is currently employed to explain why some children or adults achieve better results than others in study or work, while expending the same amount of effort. There is a general feeling that to say of someone, "He is an able person", tells the whole story. However, if we were to request a person frequently employing this term to explain what he has in mind, he might become as embarrassed as Molière's doctor when asked why opium makes us fall asleep; his answer was: "Because it has an ability to make us sleep". As all his other answers were equally illustrative, he got a good beating. When he then asked why he was beaten, the answer was: "Because the stick has an ability to beat."

Although we are spared this treatment, our reference to ability is scarcely any more revealing than that in the case of Molière's ridiculous doctor. To say of someone, "He is an able person", is to ascribe to him a property of which our only knowledge is that it exists in him. A tutor describing his pupil as, "Lacking abilities", has rarely any other grounds than his own inability to discover the roots of this deficiency — which in many cases lie in unfavourable conditions of development, such as inefficient education. In fact, there are few concepts equally well suited to concealing our ignorance

and reluctance to seek for the deeper roots of a phenomenon, which create the appearance of explaining it at the same time.

Does psychology provide an effective means of overcoming this ignorance? It does, but only in part. One of the most intriguing, but also highly complex problems of psychology, the nature of abilities, remains open to further inquiry. On various occasions investigations are pursued along lines which ostensibly defy all attempts at reconciling basic notions and co-ordinating research. Some psychologists eagerly investigate selected aspects of the problem, disregarding all others, in spite of their mutual dependence. It is significant that work done by Western psychologists is largely aimed at the selection, measurement, and classification of the basic abilities (factors), although Soviet psychologists are mostly concerned with the origination and evolution of abilities, and their physiological and psychological mechanisms.

No satisfactory theory of abilities is available as yet, and the data concerning the structure and development of some abilities, among them the intellectual abilities, are numerous. This is why this attempt to acquaint the reader with the present state of research on intellectual abilities is neither an easy, nor a particularly rewarding task. The author has embarked upon it in the hope of unearthing some instructive and fertile ideas, rather than to provide a comprehensive and harmonious picture.

The concept of ability is equivocal and ambiguous. Its colloquial meaning is very broad, covering anything between faculty, capability, and skill. This meaning is implied in such phrases as, "A is an able doctor" and "B is an able lawyer, you may rely on him", which mean that the person in question deals successfully with all difficult problems in his professional field.

With this meaning in view, English and American psychologists define ability as the actual level of efficiency in dealing with problems of a given type (Definition No. 1). A different kind of definition is current in Soviet literature: Abilities (*sposobnosti*) are those qualities of the mind on which success in a given field of human activity depends (Definition No. 2). The reader will have noted the difference between the two definitions: the first refers to actual achievements which lend themselves to objective observation and perhaps even measurement, while the second views ability as a set of internal qualities conditioning these achievements. Internal qualities are not

apparent to objective observation and their existence may be inferred only from an individual's actual achievements in a given field; none the less they are the real subject matter of all our deliberations on "abilities".

The crux of the matter lies not so much in defining the difference between the achievements of A and B, as in explaining the reasons for this difference and the chances of making B achieve better results.

As for Definition No. 2, it should be noted that those who define abilities as conditions of success in some type of activity, do not refer to all kinds of conditions and, more especially, do not take account of such things as interests, temperament and volition. Therefore this definition is imprecise and does not meet the requirements of logic. Various Soviet psychologists attach to it a much narrower meaning, but they are not consistent. For example B. Teplov does not include habits and skills among the constituents of ability, while the most recent writers on this subject, Rubinshteyn and Leontev, consider habits and skills as integral parts of ability. Leontev at times goes so far as to identify abilities with what are commonly called habits and skills.

What, then, is the real meaning of ability? This question is not easy to answer. Some hints could be derived from an analysis of the interdependence of those mysterious factors hiding behind the term ability and the process of learning, that is, the appropriation of information, skills and habits. The obvious fact is that when two persons learn the same material in identical conditions (i.e. level of knowledge, interests, means of instruction, time allotted, and technique of learning), the more able individual is bound to make better progress. A further definition could be coined with reference to those internal qualities which determine the speed and facility of learning. Abilities are those internal conditions of man on which depend facility of learning and speed of comprehension (Definition No. 3). This meaning is fairly accurately represented by the English term aptitude. Evidently Definition No. 2 is contained in Definition No. 3, being wider in scope for learning is undoubtedly a factor in the successful accomplishment of a task.

The language of psychology uses all three meanings of the term ability in a highly adventitious way. In spite of the distinction between the terms ability and aptitude, American psychologists tend

to regard them as interchangeable. A similar discrepancy is evident in their reference to tests devised for measuring abilities as "aptitude tests"; this inconsistency may be attributed to the wide-spread wish to test aptitudes *per se*, since it would be far more essential to ascertain a person's capacity to learn than his actual competence.

The above discussion has by no means exhausted all the possible meanings of the term ability; however, it should have made the reader aware of the vagueness of the term.

The present author, in reporting on the experiments of psychologists who adhere to Definition No. 1 or 2 will employ the term ability in accordance with their usage.

THE MEANING OF INTELLIGENCE

The abilities of a man fall into three groups: (1) intellectual abilities, (2) perceptual abilities (for example pitch discrimination), and (3) psychomotor abilities (for example finger dexterity).

In each of the groups numerous primary abilities are distinguished; we now know of many more than when common sense required that we view memory and thinking as unitary and indivisible abilities.

Whenever talking of abilities, we invariably associate them with intelligence. Even in the early years of this century arguments and investigations on intellectual abilities had focused on the concept of intelligence. For us this is sufficient reason to devote special attention to it.

The human being owes his splendid career among the species to his intelligence above all. Apart from cases of mental sub-normality, even the dullest human being is far superior in intelligence to the cleverest animal. Thus man was fully justified in demanding for himself the proud name of "*Homo sapiens*", or intelligent man. It is a matter of individual views already if conflicts make people contest each other's right to call themselves wise and intelligent.

What, then, is intelligence?

We are often surprised at the purposefulness and precision of some animals' behaviour when directed to the preservation of themselves and their species. Nest construction, food storage for winter, the long journeys accomplished by some species of fish and bird, the placing of eggs by insects to ensure for them adequate nutrition, are examples of the type of behaviour which has always led man to

ascribe some kind of reason or wisdom to these animals. A closer study of this phenomenon, however, has revealed its rigid and innate nature: although they are useful and show purpose, such actions are not accompanied by insight on the part of the animal, and are performed in an automatic manner. This kind of behaviour came to be called instinctive. Instinct enables the animal to adjust to a given type of environment with great precision. Owing to the inflexible and stereotyped nature of instinctive behaviour, any unexpected change in the environment may render such behaviour ineffective.

To a certain, though limited, extent the animal is capable of adjusting its behaviour to a changing environment. Such unconventional modes of behaviour are made possible by the animal's ability to form habits, also known as chained conditioned responses. Habits are conventional forms of behaviour, too, yet they derive from the past experience of the individual, instead of being an innate gift of the species. A habit forms gradually as a result of the animal's repeated and stereotyped reaction to the same type of environmental change: wild animals learn to find their way back to places abundant in food, a dog may be trained to go shopping with a basket, and in the laboratory the rat learns its way through the maze and receives food in reward. Circus training represents the peak achievement of the animal in terms of habit acquisition. Numerous habits form in man also, but a sudden change of external conditions may easily prove them ineffective. The point is that a habit is only a conventional form of adjustment to definite external conditions.

Now, what happens if both instincts and habits fail to meet an entirely new situation? The animal behaves in a violent but incoherent manner. A cat will rage about a cage, grind its teeth against the iron bars, and try to force its way between them; it makes a series of haphazard trials in response to the new situation, which either lead to exhaustion and are eventually abandoned, or result in hitting upon the right action by pure accident: in the course of its chaotic movements the cat happens to press a lever which opens the door of the cage. When the animal has repeatedly hit upon the solution in the same situation, it is apt to develop an appropriate habit. This is bound to be a laborious process, since the animal does not consciously associate the gaining of liberty with pressing the lever. The cage-opening habit is formed gradually and spontaneously by an unconscious elimination of ineffective and hence redundant

movements and the retention of successful ones which become reinforced by the subsequent satisfaction of the urge to escape.

A different type of behaviour occurs with the conscious grasp of a new situation, when a series of actual, or merely conceptual ("in the head") trials are made with full awareness of the various elements and relational aspects of the problem. This allows for an immediate adjustment of behaviour to meet the requirements of the new situation. This particular kind of flexibility and adaptability of behaviour was called "intelligent" and the creatures capable of such behaviour were considered as exhibiting intelligence. Intelligence, present in some animals in a very rudimentary form, has become fully developed in man, in close union with the development of reasoned thought.

This practical aspect of intelligence is borne out in the well-known definition of the German psychologist William Stern: Intelligence is the ability to meet new requirements by an appropriate application of thought processes (118). Two basic features of intelligence are stressed in this definition:

1. Intelligence manifests itself in situations new to the individual.
2. The gist of intelligence is contained in thinking.

Yet Stern's definition may prove inadequate from a psychological viewpoint: its plain reference to thought processes greatly diminishes its descriptive value.

This concept of intelligence finds its widest application in describing the whole range of man's mental capabilities. On the other hand, the most common and convenient measure of mental development is provided in the individual's store of knowledge. We know from day to day experience, however, that the most accurate data on man's knowledge give no clue to his ability to apply it in novel situations, nor to his facility of acquiring further information. Human beings differ at least as much in this way as in their store of knowledge; moreover, there is no reason to believe that the latter difference is more important than the former. In fact when speaking of a level of intelligence, we think in most cases of individual differences in employment of past experience and acquisition of new experience, rather than in the total store of knowledge. It seems inevitable therefore to acknowledge in our definition of intelligence those qualities of the mind which directly determine the individual level of intelligence.

Quite a few definitions were advanced with this aim in mind. Some consider the ability for abstract thought as the basic feature of intelligence. Others define intelligence as the ability to learn, and chiefly we have this latter meaning in mind when speaking of the intelligence of animals. An animal is called more intelligent if it learns more quickly, that is if it requires fewer trials to form a new habit, or is able to learn more, than the other animal. In this way dogs are more intelligent than rabbits, or hens. Even in the case of human beings, learning can be a measure of intelligence to some extent.

For the French psychologist Binet, who was one of the founders of the intelligence test, intelligence is what enables the individual to take and maintain a direction without becoming distracted, to adapt means to end and to criticize his own attempts at problem solution with a view to overcoming apparent solutions.

The English psychologist, Spearman, and the German, Anschütz, both saw the essence of intelligence in relational thought.

As in the early years of this century, psychologists are still unable to agree upon one common definition of intelligence. Wechsler, an American psychologist, defines intelligence as the aggregate ability of an individual to act purposively, think rationally, and be successful in his environment. Perhaps the most comprehensive description is given in the definition advanced by another American psychologist, Stoddard: "Intelligence is the ability to undertake activities that are characterized by (1) difficulty, (2) complexity, (3) abstraction, (4) economy, (5) adaptability to a goal, (6) social value, (7) the emergence of originals; it must also maintain such activities under conditions that demand concentration of energy and resistance to emotional forces" (120, p. 4).

There is one more definition which is of special importance to us, since it stresses the dependence of intelligence on trained thought processes. It was advanced by the outstanding Polish psychologist, Stefan Szuman, who also chose a special term: "effective intelligence", and defined it as the level of intellectual experience reached as a result of exercising the mind, coupled with the ability to make use of this experience when confronted with novel situations and new problems (123).

This great variety of definitions (those mentioned represent only a fraction thereof) is due, amongst other things, to the lack of a

uniform theory of intelligence which would meet the requirements of at least a majority of investigators. Small wonder then that there is a tendency to omit any psychological description of intelligence by saying, "Intelligence is that which an intelligence test measures."

It is evident that the most adequate definition cannot replace a detailed description of the phenomenon in question. It therefore seems advisable to discuss first some attempts at working out a theory of intelligence, in order to continue with a characteristic of people with different levels of intelligence.

THE PRIMARY MENTAL ABILITIES

In order to understand the nature of intelligence correctly it is essential to know its internal structure: is intelligence an integral quality of the mind, indivisible into more elementary parts, or is it a composite of primary abilities?

In the early years of this century, when the interest of psychologists became focused on intelligence, there arose two conflicting views on this problem. In 1903, the famous American psychologist Thorndike declared that intelligence is a composite of independent ability factors. He sorted out three different forms of intelligence: abstract intelligence (expressed in the manipulation of words and symbols), mechanical intelligence (ability to handle material objects), and social intelligence (ability of social activities). The opposite view was presented one year later by Spearman, who maintained that intelligence is an integral and indivisible ability, accompanied by various special abilities. Also Stern, the outstanding German psychologist, defended intelligence as a uniform ability.

Experience with, on the one hand, people who are generally dull, lacking intelligence in any field of interest or activity, and on the other with generally bright people pleads unequivocally for the latter view. This view, however, is questioned by the results of intelligence testing, which clearly show that the same individual may score quite differently in different tests. For instance, a person may rate a high score in verbal tests involving the classification of words according to their meaning, and at the same time score low in perceptual tests involving discrimination of figures.

Spearman offered the following explanation of this discrepancy:

“The solution of an intelligence test is effected by the indivisible general ability, designed by the author as “g”, plus some special ability, or abilities. Spearman viewed this factor “g” — by analogy with physics — as a kind of mental energy. Since the level of the various special abilities may differ greatly in an individual’s score and each type of intelligence test measures, apart from the general factor, a different special ability, it is obvious that a person’s scores on each test may be quite different. In this way Spearman attempted to defend his notion of a general and indivisible factor which is involved in absolutely all mental acts. Spearman’s concept, also known as the two-factor theory, did not prevail for long.

Modern psychologists generally agree that the meaning of the term “intelligence” implies the existence of various more basic factors. There are different views, however, as to the nature and number of these factors, the most popular theory being that of Thurstone.

Employing the mathematical method of factor analysis of intelligence test scores (introduced already by Spearman) Thurstone identified a dozen or so intelligence factors, that is primary abilities, considering them as fairly independent of each other. The exact number of factors varies in the different publications of this author. For example, in 1938 (131) Thurstone distinguished two verbal factors, while later, in 1948 (132), their number rose to three. In the following extract the reader will find the now classical list of six primary factors, together with samples from Thurstone’s “SRA Primary Mental Abilities Test”. Against all appearances, the psychological nature of these factors remains a riddle. Their designation was achieved by mathematical analysis of the interdependence of a great number of test scores.

V — Verbal Meaning

(What follows is the opening—and therefore the easier—part of Thurstone’s appropriate test, together with instructions.) The first word in the following line is BIG.

A	B	C	D
A	B	C	D
A	X	C	D
A	B	C	D
A	B	C	D
A	B	C	D

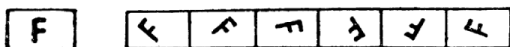
One of the other words means the same as BIG. This word is Large. Large is answer B. An X has been marked on B in the Answer Pad. (130) In each of the following problems, mark an X in the box of the word that means the same as the first word.

BIG	A.Ill	B.Large	C.Down	D.Sour . . .	A B C D
MOIST	A.Curt	B.Humane	C.Damp	D.Moderate	A B C D
QUICK	A.Major	B.Hasty	C.Narrow	D.Vigorous	A B C D
ANNUAL	A.Variable	B.Yearly	C.Listless	D.Untenable	A B C D
SPLENDID	A.Expensive	B.Gay	C.Rigid	D.Excellent	A B C D
CUSTOMARY	A.Nocturnal	B.Radial	C.Prime	D.Usual	A B C D
FLUID	A.Livid	B.Dead	C.Liquid	D.Talkative	A B C D
IDLE	A.Lazy	B.Cross	C.Wild	D.Useful	A B C D
DESERTED	A.Drab	B.Absurd	C.Disturbed	D.Abandoned	A B C D

S — Space Factor

Look at the row of figures below. The first figure is like the letter F. All the other figures are like the first one, but they have been turned in different directions.

Now look at the next row of figures. The first figure is like the letter F. But none of the other figures looks like an F, even if they were turned right side up. They are all made backwards.



A B C D E F

A B C D E F

A B C D E F

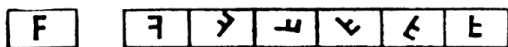
A B C D E F

A B C D E F

A B C D E F

A B C D E F

Some of the figures in the next row are like the first figure. Some are made backwards. (...) In the row of figures below, mark an X in the box of EVERY figure which is LIKE the first figure. Do NOT mark the figures which are made backwards.



	A	B	C	D	E	F	A	4	4			
							A	B	C	D	E	F
							A	B	C	D	E	F
							A	B	C	D	E	F
							A	B	C	D	E	F
							A	B	C	D	E	F
							A	B	C	D	E	F

R — Reasoning

Study the series of letters below. What letter should come NEXT?

a b a b a b a b

The series goes like this: ab ab ab ab. The NEXT letter in the series should be a. An X has been marked in "a" on the Answer Pad. Now study the series of letters below. Decide what the NEXT letter should be. Mark an X in the boxes of the NEXT letter in this series.

c a d a e a f a

a a b c c d e e f g g

a x a y b x b y c x c y d x d

a b c a b c d e f d e f g h i

c b c x y z d e f x y z g h i

a b c a b d a b e a b f

x y z a x y z b x y z c x y z

e f c g h c i j c k l c m n c

<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The other factors specified by Thurstone are:

W—Word Fluency.—The appropriate test requires the subject to write down within a certain time-limit a maximum number of words which start with a given letter, or end with a given letter.

N—Numerical Factor—is demonstrated in solving arithmetic problems. The appropriate test requires the subject to add numbers as quickly as he can.

M—Memory.

Employing a similar technique of analysis, other writers have drawn up similar lists of factors, with their exact numbers varying from case to case. Quite a number of factors are common to all these lists, others occur in only some of them.

The question now is whether Thurstone's procedure has really demonstrated **all** the essential factors in intelligence. The answer is rather negative for the following reason. The manifestations of intelligence in everyday life are of a highly varied nature, whereas the testing procedure used by Thurstone and the other authors involves only a limited range of problems and situations. Such tests

cannot cover all the essential aspects of intelligence for the simple reason that the subject's expediency is one of the assumptions of the testing procedure, and this excludes problems of a more complicated nature. For example, Thurstone's subjects have to be familiar with uncommon words and solve short problems supplied in a definite form. On the other hand, they need not exhibit any ability to identify and formulate problems, or to overcome the interference of conventional thought habits, the adverse effects of emotions, and so forth.

Standing out from among the more recent efforts at developing the factor theory of intelligence is the important work of J. Guilford (Pers, 1959) (45). His book represents a bold synthesis of the findings of earlier research and is supplemented with his own investigations based on tests specially devised for studying the creative abilities. Guilford distinguished altogether some fifty intellectual factors: there are no less than eight memory factors on his list, while Thurstone had contented himself with one. What is of special interest to us, however, is not so much the number, as the principle of this classification. Guilford developed a number of basic criteria and arranged all the factors in matrices, on the pattern of Mendeleev's matrix of elements. The advantage of this approach lies in the possibility of anticipating the existence of undiscovered factors.

According to Guilford, the intellectual factors fall into two basic groups: memory, and thinking. The latter group splits into three subdivisions: cognitive abilities, productive abilities, and evaluative abilities.

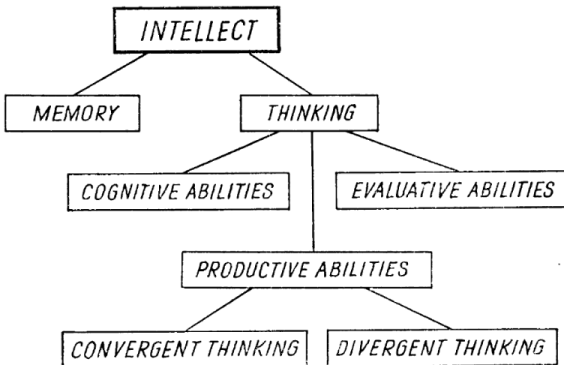


Fig. 1

Between six and as many as twenty primary abilities are included in each of the groups. A detailed presentation of all these abilities is a rather difficult task, as in some cases Guilford's description is confined to a very brief indication as to the type of test involved. This is by no means accidental: it has already been noted that American psychologists generally adhere to a one-sided mathematical analysis of abilities which does not provide a more incisive psychological description.

For the purposes of our discussion it should suffice to give a brief account of the primary abilities, as classified by Guilford under the main headings of Fig. 1.

MEMORY FACTORS

Contrary to traditional beliefs, there is no universal or general memory ability. Otherwise people with a good memory for words would exhibit an equally good memory for melody, forms, colours, etc. Convincing evidence has been supplied by numerous investigators that the same person generally has different abilities for memorizing different kinds of material. For example, F. Baumgarten (6) investigated the abilities of infant prodigies* and found that children with an excellent musical memory had only a tolerable memory for numbers, while one extremely gifted in chess and with an excellent memory for numbers, had a rather poor memory for patterns.

Guilford's memory factors are: visual memory, auditory memory, memory span (the ability to recall immediately a series of symbolic elements in correct order after a single exposure), memory for ideas, rote memory (for symbols such as letters, syllables, numbers), meaningful memory, memory for spatial order, and memory for temporal order.

* An infant prodigy (or child prodigy) is characterized by a premature and unusual development of specific abilities, bringing it on a par with highly gifted adults. Most striking is the premature development of scientific and artistic abilities. Pascal, for example, at the age of twelve, quite by himself, discovered the axioms of Euclid's geometry, and at sixteen he wrote a remarkable paper on cone dissections. Mozart began musical composition at the age of five, and already at the age of six he enjoyed world fame as a virtuoso.

It should be mentioned that such traditional types of memory as visual and auditory memory, are by no means homogenous abilities. For instance, in auditory memory at least two abilities can be distinguished: memory for musical composition heard, and memory for rhythm.

Thinking Factors are split into cognitive, productive and evaluative abilities.

1. *Cognitive Abilities* are connected with the possession of information—its discovery and rediscovery, or recognition. Their nature is mainly receptive, and some are as follows: visual, auditory, and symbolic cognition, verbal comprehension, figural and semantic classification, eduction of relations (the ability to discover relations between objects or concepts), spatial orientation, conceptual foresight.

2. *Productive Abilities* are connected with the formation of ideas. Guilford subdivides this group into convergent-thinking and divergent-thinking factors. Convergent thinking proceeds toward one correct answer, a determined or conventional answer. The following example will illustrate this type of thinking. The numbers in each of the rows below are arranged according to some principle of sequence. Your task is to discover this principle and to apply it in adding one further number in each row.

1, 3, 5, 7, 9, ...

2, 4, 8, 16, 32, ...

1, 3, 6, 10, 15, 21, ...

(The right answers for the three rows are: 11, 64, 28 respectively.)

Here are some of Guilford's convergent-thinking factors: visualization (transforming an object into another visual arrangement), object naming, concept naming, ordering (re-arranging pictures into their appropriate sequence), numerical facility.

Divergent thinking, on the other hand, occurs in solving problems with possible different answers.

Let us consider one of these problems, which involves a factor termed spontaneous flexibility. The subject's task is to name several unconventional uses for common objects. The Unusual Uses Test is introduced by pointing out to the subject that, for instance, a newspaper may also serve other purposes than reading: making fires, con-

structuring kites, covering shelves, wrapping, fitting windows, and many more. The same thing applies to other objects.

Now the subject is given the names of several objects and asked to indicate a certain number of unusual uses of each. Evidently this type of problem appeals to what is commonly called ingeniousness.

Guilford lists among the divergent-thinking factors such abilities as: word fluency (demonstrated in rhyming, for instance), ideational fluency (the naming of things which have two specifications in common, for instance, things both solid and edible), and with reference to visual perception—figural adaptive flexibility (finding faces whose lines are concealed as parts of larger objects).

3. *Evaluative Abilities* include, among others, identification of figures, logical evaluation, experiential evaluation (judgement), and sensitivity to problems.

Figure 2 shows sample items from an identification test of figures. (From Part IV of the Guilford-Zimmerman Aptitude Survey.) The

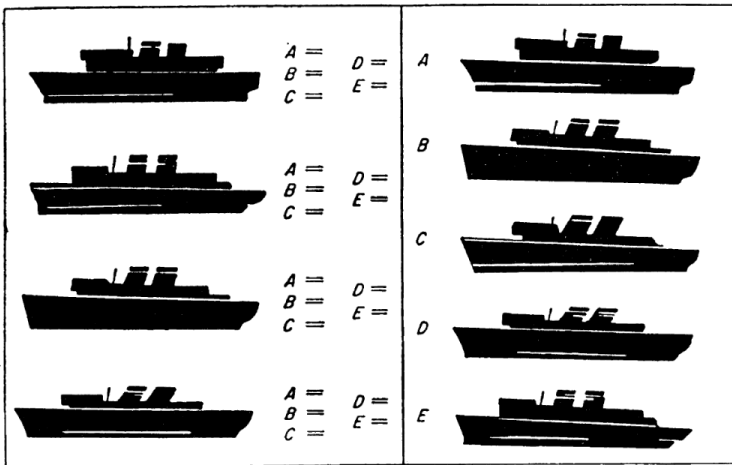


Fig. 2

task consists in establishing which ship on the left is exactly like which ship on the right.

A logical evaluation of the problems requires the subject to decide which of the suggested conclusions can be drawn from the given premises.

Example: No birds are insects. All swallows are birds. Therefore:

A. No swallows are insects. B. Some birds are not swallows. C. All birds are swallows. D. No insects are birds. (Answer: A.) (From: Guilford, *Personality*, 1959, p. 392.)

Guilford does not explain how his intellectual factors are related to intelligence. He has undertaken a more comprehensive task—to list all the possible intellectual abilities. Now, as for intelligence, we already know that it is merely a term given to a wide range of intellectual abilities, but which of the known primary mental abilities are embodied in the concept of intelligence? Certainly those which are involved in the solution of the highest number of mental problems most frequently encountered by man in the course of his learning and occupational activities. Practical intelligence testing, it should be noted, is chiefly based on Thurstone's list of intelligence factors.

Guilford's analysis of intellectual factors has produced a picture which the author himself cannot consider as final and complete. Further research is required to produce a satisfactory list of primary mental abilities. Nevertheless, the findings to date already offer some practical suggestions for education and applied psychology.

As we are seriously concerned with training our intellect, we dare not ignore any attempts at investigating its structural properties. The testing of intelligence, contrary to current tendency, should not be limited to the acceptance of an overall score as an indicator of a general level of intelligence; it should aim at elaborating the "intelligence profile", that is a description of the separate factors, or sets of related factors.

THE INTERNAL STRUCTURE OF MENTAL ABILITIES

So far we have been concerned with the types of mental abilities discernible in man. A problem of equal importance is the mechanism and the internal structure of these various mental abilities. This problem is left aside by Guilford and the other psychologists who employ tests as a means of recording the external manifestations of the abilities in their static, not dynamic, state.

In order to get a glimpse into the internal, that is the psychological, structure of the abilities, we shall have recourse to the recent findings and theories of Soviet psychologists.

We can infer individual differences in abilities from the subject's final performance, as represented by his test scores. This approach, however, does not provide the slightest clue as to the nature of the abilities. The recorded performance of tested subjects is the outcome of internal processes; hence the need to study all phases of the subject's performance, not merely its final results. In our search for the true nature of mental abilities, we shall have to study the subject's perceptions and thought processes in the course of solving different kinds of tasks and problems. Such assumptions have prompted a famous Russian psychologist, Rubinshteyn, to undertake investigations designed to answer the question about the psychological structure of mental abilities and their various constituents. His attempt will become fully intelligible after we have discussed an experiment conducted by V. Krutetsky, who tried to explain the internal structure of mathematical abilities in line with Rubinshteyn's conclusions.

Krutetsky's approach consisted in comparing the performance of schoolchildren (rated as highly gifted, average, and below average in mathematics by their teachers) in solving algebraic problems and in mastering new algebraic skills.

In accordance with the opinions voiced earlier by many authors, this investigation demonstrated substantial individual differences in the facility and speed of generalizing mathematical material. One of the experiment series began with acquainting the subjects with a formula of simplified multiplication, known as the square of the sum: $(a + b)^2 = a^2 + 2ab + b^2$.

The subjects were then presented with a series of problems of increasing difficulty, each of which could be solved by means of the basic formula, though in purely external terms they were less and less similar to the original.

- | | |
|---|--------------------------------------|
| 1. $(a + b)^2 =$ | (m5. $+x^4 + b)^2 =$ |
| 2. $\left(1 + \frac{1}{2} a^3 b\right)^2 =$ | 6. $(4x + y^3 - a)^2 =$ |
| 3. $(-5x + 0.6xy^2)^2 =$ | 7. $51^2 =$ |
| 4. $(3x - 6y)^2 =$ | 8. $(C + D + E) \cdot (E + C + D) =$ |

It is quite obvious that the original formula most easily fits problem No. 2, while the subsequent applications are of increasing

less gifted student is scarcely capable of making generalizations about the available material, and of noticing the similarity between the general formula and the concrete problems of a modified form.

By contrast, the behaviour of the gifted student is characterized by quick generalization of the mathematical material, finding expression in the immediate application of a known formula to new and apparently dissimilar problems. One such pupil succeeded in solving problem No. 8 on its first presentation, without being directed by the series of guiding (pilot) problems:

$$(C + D + E) \cdot (E + C + D) = (C + D + E)^2.$$

And then: $[C + (D + E)]^2$.

This subject also noticed immediately the applicability of the basic formula to problem No. 7 : 51^2 . He solved it in his head by substituting the formula: $(50 + 1)^2 = 2601$.

Krutetsky draws the following conclusion from this experiments: Other things being equal—the more gifted a student in mathematics, the quicker and broader his generalizations of the mathematical material. In addition, gifted subjects very quickly curtail their reasoning processes when problems of the same type are repeated (that is, they discard the laborious formulation of all the premises, one by one); they are also quick at grasping the reversed procedure, once being acquainted with its proper course.

This investigation is by no means sufficient to explain all the types and constituent elements of mathematical abilities. However, it provides an instructive illustration of Rubinshteyn's ideas on this subject and at the same time lends them support.

Rubinshteyn maintains that any matured ability contains some acquired patterns of performance (operations), serving the musician, joiner, mathematician, or any other expert in their job. These operations, or performance patterns, result from the experience of many generations and may take the form of habits. They have an enormous influence on the effectiveness of human performance. To define an ability as merely the sum total of acquired operations would be to underestimate the complexity of the problem. It is obvious that, although two people may have the same store of acquired operations, one may employ them quicker and more effectively, according to the prevailing conditions, than the other. The subjects of the experiment reported above are a useful example;

their operations took on the form of mathematical expressions. The most essential elements of the intellectual abilities, according to Rubinshteyn, are contained in certain mechanisms which regulate the application of concrete operations, and also facilitate their acquisition.

These processes were identified by Rubinshteyn as (1) Analysis (isolation, discrimination) and (2) Generalization of relationships in the field served by the given ability. Thus an extremely gifted individual in mathematics may be recognized by his quick generalization of the relationships inherent in the mathematical material (that is, he requires only very few examples to grasp the inherent principle). Similarly, an individual of special linguistic talent is quick at isolating and generalizing the relations (rules, similarities, interdependencies) underlying word-formation, inflexion and syntax.

In this way individual differences in the various mental abilities find expression in the varying facility and speed with which individuals analyse and generalize the relations inherent in the appropriate sphere of problems. There is no universal ability of isolation and generalization of relations: an individual may possess it in one sphere of problems and lack it in many others. Though Rubinshteyn's processes of analysis and generalization may be a common element of various mental abilities, they will always have some specific feature responsible for individual differences in abilities.

It should be remembered that Rubinshteyn's theory is but a hypothesis calling for confirmation and elaboration by further investigations. This applies particularly to his contention that analysis and generalization are the core of not only some, but absolutely all, mental abilities.

This hypothesis is the outcome of an effort to overcome the traditional separation of research on mental abilities from that on thought processes; it can therefore thrive on firm and fertile ground. I venture to say that, in forming his hypothesis of abilities, Rubinshteyn was greatly influenced by his own studies of thinking (some more details of this are presented in our chapter on problem solving). The practical significance of this hypothesis is that it calls attention to the most crucial aspects of acquiring skill and improving abilities.

below the normal level of intelligence in a three year old child. He may be somewhat more advanced in his social development, but in this respect also he will remain below the level of a four year old child. He is incapable of looking after himself and needs constant care throughout his life. According to a study by E. O. Lewis idiots constitute 5 per cent of all the mentally deficient.

Imbecility

Imbecility is the intermediate level of mental deficiency. Unlike an idiot, an imbecile can learn to speak tolerably well, but is unable to pass an elementary school course successfully. Even after a few years of study he can neither read correctly, nor solve the arithmetical problems contained in the curriculum. At the most he is able to learn by heart some simple information, but only with great pains and without understanding it. The memory of imbeciles is generally very poor. In some cases, however, imbeciles develop an unusual, but specialized, rote memory (for either melodies, or numbers, or names etc.)

Imbeciles concentrate with great difficulty and can be easily distracted. Their thinking is very rudimentary and is of a purely concrete type, far from the abstract thinking of a normal individual. That is why they are absolutely unable to make comparisons, to perceive relations, to make use of their experience, to summarize, to foresee, to criticise, and to generalize. Imbeciles are extremely suggestible. They commit crimes without being aware of it, sometimes under outward influence. They can cope only with simple life problems and perform only very simple work to earn their living (herd cows, plait straw, etc.).

The mental growth of imbeciles, measured by intelligence tests, reaches its peak at the age of ten to twelve and it oscillates in the range of the intelligence levels of normal three to seven year old children. Their social development, which is estimated from their ability to accomplish various practical everyday functions, remains at the level of four to nine year old children. According to Lewis, imbeciles constitute about 20 per cent of all mental defectives.

Feeble-mindedness

Feeble-mindedness is the mildest, and at the same time the most frequent form of mental deficiency (about 75 per cent of all the

mentally deficient). It is sometimes difficult to distinguish a higher grade moron from a normal person.

Unlike the imbecile, the moron may be able to graduate from elementary school, though only with the utmost difficulty, often staying for a few years in the same form. In order to provide the most suitable conditions of learning for morons and imbeciles special schools are organized with methods of teaching adapted to their mental level. The mind of the moron shows many of the handicaps found in an imbecile, though these are less accentuated. Thus, morons concentrate with difficulty, their thinking is concrete, they have little ability to understand and perceive relationships and they apply knowledge in a mechanical way, without proper understanding. Their minds work slowly and they can only manage some mental effort when forced by their teachers.

A moron is capable of elementary abstraction, but his conclusions are restricted and he cannot make use of his knowledge in a new situation. When he has to solve a more complex problem, he will constantly repeat the same attempts, much more stubbornly than a normal individual, despite the fact that those attempts produce no result. This demonstrates that his thinking is inflexible, dull and lacking in versatility.

A moron, however, can manage simple life affairs and in favourable conditions he can learn some simple vocation and earn his living, though he is incapable of working independently. According to intelligence tests the mental growth of morons is at the level of 8-12 year old children, but their social development may reach the level of 18 year olds.

It follows from the above considerations that an intact structure and the normal functioning of the brain is an indispensable condition of normal intelligence. Upbringing and education are further conditions for a full development of intelligence for they provide an individual with the tools of thinking (in the form of language) and with knowledge—as elaborated by previous generations. By imparting knowledge, the educational institutions train the mind and furnish it with the means of thinking, without which it is impossible to attain that intellectual growth which is considered normal in a modern society. There have been cases of children who were considered to be mentally deficient, who have not attained the intellectual level

only upon old foundations, and leant upon principles which, in my youth, I had taken upon trust." (26, p. 12.)

But though Descartes subjected to the scrutiny of his reason all the views enforced on him by his contemporaries, he could not help re-instating—even with his amazingly imaginative and critical judgement*—part of the methaphysical heritage of his time, which—it should be noted—proved only a minor obstacle for less judicious minds in subsequent centuries.

No man could possibly manage to check, by himself, every single fact and assertion he is confronted with in his personal intercourse with other people, or those he learns about from books. Should anyone try to do this, his actual knowledge would accrue at a snail's pace, and his critical judgement could crawl only on the dwarfish legs of his personal experience. Therefore a person of critical mind does not refuse to accept certain authorities. These cannot be accidental or self-styled. He will accept the opinions of competent experts who can afford to be unbiased. Thus the critical mind is used to examining the competence of the authority before accepting his judgement. Neither does the critical mind worship blindly and authority accepted in this way, but he is rather on his guard and always prepared to put the question: Is it not that my mentor is mistaken on this point? Should I not check his opinion with a further authority? This is the precise point on which the critical mind differs from the dogmatic mind.

Dogmatism implies the uncritical acceptance of assertions only on the account that they were propounded by an accepted authority, the competence of which has never been questioned. This implies an uncritical attitude in at least one specific sphere of problems. Dogmatism occurs also when someone is unable to modify his established opinions even though they have been disproved by the advance of science. Dogmatism may result either from vested group interests and personal engagement, or from mental routine and dullness, which confine the mind to habitual trains of thought. Whatever its source, dogmatism is undermined by the increase in mental skill, just as superstition is overthrown by the advance of science.

* It was Descartes who paved the way to a naturalistic interpretation of human behaviour by conceiving the concept of *reaction (response)*, though the term itself was introduced later on.

In some people the critical attitude is restricted to a definite range of problems. History tells us about scientists or scholars who combined an unparalleled criticism in their vocational field with unrestrained dogmatism in matters of life philosophy or political attitudes which they had endorsed in good faith from their social environment.

Some other people, again, are critical only of other people's views, whilst uncritical of their own. Self-criticism is perhaps the most intractable type of criticism, unless produced by a complex of inferiority. A classical example of this attitude of doubt was given by Socrates who, apart from challenging other philosophers, did not hesitate to admit publicly that the only thing he knew for certain was that he knew nothing.

It has been stated already that a person of superior mental culture not only has a critical mind, but a rigorous one also. A person with a rigorous mind should be expected to approach all problems with due precision, being acquainted with the principles of definition, classification, measurement, computation, and testimony. It is this strict manner of thinking which imprints on the critical mind the mark of true mental culture and guarantees the appropriate stringency and effectiveness of performance, in both the critical and creative spheres.

Criticism and strict thinking do not necessarily go hand in hand. Numerous people are capable of a critical analysis of the most widely accepted standards; far fewer are in command of the mental procedures enabling them to avoid superficiality and cursoriness in dealing with problems. Once subjected to a critical scrutiny of reason, many of our controversies and conceptions prove pointless. Evidently their existence was based on misconceptions, fallacies, ambiguities, and figments of imagination.

In order to develop his critical powers, a person does not need much more than a fairly bright mind. Rigorous thinking, however, is much more dependent on scrupulous training in logic and the methodology of mental skill. Few people are given the opportunity to experience the exacting guidance of such masters of rigorous thinking as, for instance, the Polish philosopher Kazimierz Twardowski.

THE OBSTACLES TO AN IMPROVEMENT OF MENTAL CULTURE

The development of criticism in thinking is hindered by numerous obstacles. These were analysed by philosophers concerned with the advance of mental culture in past centuries. Francis Bacon, having enumerated the types of illusions which prevent us from knowing the truth, writes:

“The human Understanding does not resemble a pure light, but admits a taint of the will and passions, which generate their own system accordingly; for man always believes more readily that which he prefers to believe. He therefore rejects problems for want of patience in investigation; sobriety, because it limits his hope; the depths of Nature, from superstition; the light of experiment, from arrogance and pride, lest his Mind should appear to be occupied with common and varying objects; paradoxes, from fear of the Opinion of the vulgar; in short, his feelings infiltrate and corrupt his understanding in innumerable and sometimes imperceptible ways”. (3, p. 21.)

Psychology has been able to pin down some of these “imperceptible ways”. Let us consider two such processes, known in psychology as “rationalization” and “projection”. Not everybody will have experienced them, yet their fatal consequences for our faculty of self-appraisal should be obvious to every one.

The fairly frequent phenomenon of rationalization is demonstrated when a person inadvertently thinks up virtuous motives or rational sources for his actions that in fact are devoid of it. This happens, for instance, when someone lends his assistance to a person in need and claims to be motivated by altruism, while in fact it is but a cold calculation of his own benefits, proof of which is given when the other has been deprived of his influence or riches. Another example of rationalization is the desire to conceal defeat by persuasion that the whole thing was not worth the effort.

What is meant here is not the deliberate distortion of our motives for the benefit of the outside observer, but rather the inadvertent submission to pleasant illusions about oneself, while preserving criticism of other people. Back in the 17th century La Rochefoucauld described this in his pithy aphorisms, such as “We are far from being aware of all our urges”. “It is as easy to deceive oneself without

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