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2.1 INTRODUCTION

The critical question of this period of human history - the answer to which must also come from the critical use of man's mind - is whether or not human intelligence as traditionally defined offers any reliable assurance of human survival. This question may seem hopelessly abstract, even trite. But nothing could be more concrete. Is pure intelligence enough to protect man from self-inflicted destruction?

Among a group of children at play, we spot those who seem to be bright and those who seem to be dull in catching on to the rules of the game and as we watch them at school, we make a distinction also between bright and dull. We frequently encounter representatives of the extremes.

Aristotle rightly says, "Reason, in the sense of intelligence is not found equally in all animals, nor in all men." Distinctions in intelligence are recognized and used almost every hour of human lives. The teacher or the educationist responsible for the education of individual children from the beginning, is supposed to know as to what is understood by intelligence, what is its real nature. Sometimes teachers in the classroom and even many educational administrators are not very clear about the concept of intelligence. For example, if a teacher is asked to point out the most intelligent pupil in the class, he very often points out a quiet, shy child who gives no trouble, comes to the class regularly, does his homework regularly and is no problem to the teacher and the teacher thinks that this boy is very good in his behaviour and routine classwork and is thus very intelligent. He may, on the other hand, point out another child who is rather aggressive, rowdy, sometimes cutting classes, not doing his homework regularly and even sometimes questions the teacher in the class and enters in an argument. He may be labelled as a bad boy, and may be called an ass. But if intelligence of these boys is judged, the former may be found to be having I.Q. near about 100, whereas the second child who is active and restless may be found to have an I.Q. of 125. To the teacher, ordinarily good behaviour stands for good intelligence, but it is known that good behaviour is different from intelligent behaviour.
The confusion, therefore, arises when the meaning of intelligence as a concept is not understood. It is among the most elusive of concepts. Certainly, there are few other concepts that have been conceptualized in as many different ways. The various conceptions of intelligence that have been proposed have usually sounded related to each other; unfortunately, the nature and extent of the inter-relations remain fuzzy.

2.2 DESCRIPTIVE CONCEPTIONS OF INTELLIGENCE

2.2.1 Definitions of Intelligence

In popular understanding, intelligence means mental abilities enabling one to think rationally, learn readily, act purposefully, and deal effectively with one's environment. In psychological testing, it is a term that has been given many different technical meanings concerned with mental abilities such as verbal reasoning, quantitative thinking, abstract analysis, manipulation of geometric shapes, recognition of similarities and differences between pictured objects.

Intelligence also implies "intellect" as

(a) Capacity: Capacity or power of the mind for thinking and knowing in contrast to those mental faculties by which the individual feels or wills.

(b) Figurative: Figurative references to individuals with marked capabilities for thought, or to thinking powers, in general.¹

According to the Dictionary of Psychology,

'Intelligence' refers to the ability to function effectively with problems, whereas 'intellect' refers to the rational thought functions of the human mind.²

With the invention of mental tests, the question "what is intelligence" took a different turn. Psychologists proved to be generous to a fault with their definitions of intelligence. A number of definitions has been evolved by psychologists according to their own concept of the term but no two psychologists agree on a single definition of the term.
2.2.2 Intelligence: Origin of the Concept

According to Cyril Burt, the term intelligence goes back to intelligentia, a term introduced by Cicero. The former, then, adds, "As Guilford has reminded us, the modern notion of 'intelligence as a unitary entity' was a gift to psychology from biology through the instrumentality of Herbart Spencer." ³

According to Spencer,

during the evolution of animal kingdom, and during the growth of the individual child, the fundamental capacity of cognition "progressively differentiate in a hierarchy of more specialised abilities" - sensory, perceptual, associative and relational, much as the trunk of a tree sprouts into boughs, branches, and twigs.⁴

After the first scale of intelligence measurement was published by Binet and Simon, psychologists tried to study and define the term intelligence critically. Symposia were held on the problem, and numerous voices were heard. As Spearman put it, intelligence became a "mere vocal sound, a word with so many meanings that finally it had none."⁵

It would not serve much purpose; rather, it would be a dull affair to give a mere parade of definitions. Instead, definitions of intelligence given by Binet and Terman who were totally concerned with the Binet scale and its American revisions respectively are dealt herewith, with some comments thereupon.

Binet, a pinnacle among mental testers, had his views about intelligence but he never stated a formal definition of intelligence in a published form. According to Hollingworth, "Binet emphasized three phases of behaviour: (1) the ability to take and maintain a given mental set; (2) the capacity to make adaptations for the purpose of attaining a desired end; and (3) the power of auto-criticism."⁶ Guilford adds, "Still later, Binet added a fourth step, comprehension. With the four steps of direction, comprehension, invention and criticism, Binet's description of thinking or problem solving is quite congruent with recent thinking."⁷
Binet stated that,

"The mental faculties of each subject are independent and unequal; with little memory there may be associated much judgment.....Our mental tests, always special in their scope, are each appropriate to the analysis of a single faculty."\(^8\)

Guilford comments that by the use of the term faculty, Binet was not committing himself to the philosophical tradition of faculty psychology. The former, then, adds:

"It is obvious that Binet did not carry his conception of independent faculties to the logical conclusion in terms of measurement. In the practical situation in which he found himself, all he needed was a means by which to reach a single administrative decision about each child. A single score was a natural means to that end."\(^9\)

Terman makes intelligence synonymous with abstract thinking in his statement, "An individual is intelligent in proportion as he is able to carry on abstract thinking."\(^10\) According to Rex Knight, "Terman gives emphasis on abstract thinking but neglects the process of perceptual level of thinking. The definition ignores the fact that undirected abstruse thought is as little intelligent as undirected observation. Again, it assumes that the capacity for abstract thinking is simple and indivisible, whereas, in fact, it is a compound ability comprising more than one power."\(^11\) Rex Knight, then concludes that "the capacity for abstract thought, like all other abilities, involves factors specific to itself as well as intelligence, and therefore to identify it with intelligence is a mistake."\(^12\)

Many more definitions with their respective comments can still be added but it would not be of much use. For a long time, it was fashionable to set down as a definition the statement that intelligence is what the intelligence tests measure. Commenting on the definitions of intelligence, McNemar humorously states that, "..... it might be claimed that no definition is required because all intelligent people know what intelligence is; it is the thing that the other guy lacks."\(^13\)
2.2.3 Comprehensive Definitions of Intelligence

"The attempt to compress the concept of intelligence into a compact definition is too complex, too many-sided, too wide-ranging and too vague."\(^{14}\) Accordingly, there have been various attempts to describe it in a more comprehensive manner rather than define it in a compact form. The noteworthy attempts to define intelligence comprehensively are those of Stoddard, Wechsler, Piaget, Thorndike and Hebb; the last two, of course, describe types of intelligence. Here, the contributions of Stoddard, Wechsler, E. L. Thorndike and Hebb only have been briefly discussed.

**Stoddard's description**

Stoddard describes intelligence, treating it as a theoretical composite whose elements may be operationally tested.

Intelligence is the ability to undertake activities that are characterised by (1) difficulty, (2) complexity, (3) abstractness, (4) economy, (5) adaptiveness to goal, (6) social value, and (7) the emergence of originals, and to maintain such activities under conditions that demand a concentration of energy and a resistance to emotional forces.\(^{15}\)

Difficulty which is a function of the "percentage passing" as well as a function of population must increase with chronological age, so long as mental growth is postulated. Stoddard remarks that, "it must be, to be meaningful, truly hierarchical and not simply a broadening of the base." Complexity is referred to the breadth or area of intelligence. In other words, it refers to the number of tasks that can be successfully undertaken by the individual. For Stoddard, the third attribute of abstractness "lies at the heart of intelligence."\(^{16}\) It is the key characteristic of all high level mental operations.

Coming to the fourth attribute of intelligence, Stoddard remarks that economy is another name for speed - the accomplishment of the most mental tasks in the least time. However he prefers the word "economy" for speed for the latter
implies fast motion without sufficient stress upon direction and accuracy. While discussing the fifth and the sixth attributes, Stoddard states that the adaptiveness to a goal and social value tend to merge. "Regardless to the test content revealing these attributes, the first reference point is to individual behaviour and the second to the more slowly changing mores."17 The seventh one, the emergence of originals, is included, as one attribute because of its special place at the upper end of any valid distribution of intelligence.

**Wechsler's description**

In the preface of the fourth edition of his work, published in 1958, Wechsler writes that his views on the nature of intelligence have not changed radically but that he has become increasingly convinced that intelligence is most usefully interpreted as an aspect of the total personality.18

As per Wechsler,

> Intelligence is the aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment. 19

The definition specially states that an individual's intelligence is revealed by his behaviour as a whole and that intelligence involves behaviour toward a goal which may be more or less immediate. The inclusion of phrases "to act purposefully" and "to deal effectively" specifies that "drive" or "incentive" enters into intelligent behaviour. Wechsler clearly emphasizes these aspects by supporting Alexander's findings, which include a reference to such non-intellective aspects. 20

Freeman comments;

> The inclusion of "drive", "incentive" and the like as aspects of intelligence is of doubtful validity; their inclusion would confuse the issue, the testing instrument, and the results obtained..... This is not to say that in assessing an individual's intelligence and personality as a whole we should ignore "drive", "incentive", "interest"; for the competent psychological examiner does evaluate these and other non-intellectual traits in presenting his test-results. 21
It can be seen that though Wechsler acknowledges "drive", "incentive", "temperament" as basic factors in general intelligence and hold that general intelligence cannot be equated with intellectual ability, but must be regarded as a manifestation of the personality as a whole,\(^2\) he has not been able to redevise his two world-wide famous scales – Wechsler Adult Intelligence Scale (WAIS) and Wechsler Intelligence Scale for Children (WISC) – to include the measurement of the non-intellectual traits.

Wechsler, too, seems to have been quite conscious of this. In the preface to the 1958 edition of his works, he writes:

I look upon intelligence... as a resultant of interacting abilities-nonintellective included. The problem confronting psychologists today is how these abilities interact to give the resultant effect we call intelligence. At this writing it seems clear that factorial analysis alone is not the answer. Probably a new statistic involving field-theory and non-linear differential equations will be required. In the mean time, I remain a reformed but unchastened Spearmanite.\(^2\)

**Thorndike's description**

Under the effect of this era of specifications, E. L. Thorndike specified intelligent activity into three types: (1) social intelligence or ability to understand and deal with persons; (2) concrete intelligence or ability to understand and deal with things; (3) abstract intelligence or ability to understand and deal with verbal and mathematical symbols.

This division indicates the need for designing separate tests to measure how effectively the individual is functioning in each. But psychologists discordant with Thorndike's views do not think that such specialised measurement is necessary. Freeman, here, remarks that though in the case of any given person the score attained on a test of abstract intelligence might differ appreciably from those attained by him on a test of "social" relationships and insights, or on one of "concrete" intelligence, the correlations between the types of tests are found to be positive and significant, both psychologically, and statistically, when "a representative group" of individuals are tested.\(^2\)
It is an indubitable fact that tests of abstract intelligence outweigh others and are most pronounced in current tests of intelligence which are designed for use with persons, who are presumed to have developed facility in dealing with concepts and symbols, on the grounds of maturity. The testing of concrete intelligence is usually restricted to the earliest developmental levels but it has only slight predictive value for later development of mental abilities. As Freeman observes, even tests that present the subject with "things" rather than with ideas and symbols are not devoid of demands upon ability to conceptualize and make abstractions, although the subject need not necessarily respond in the form of language and number. 25

2.2.4 Intelligence and The Present Experiment

Since every theory may still be regarded to be in the experimental stage, it is very difficult to accept any one of them, and then to construct tests to suit it. The investigator has looked to the practical side of the matter without any theoretical prepossessions and selected the tests for the battery.

It is necessary for a test constructor to know what exactly is to be measured by the instrument which he or she is going to prepare. Therefore a clear understanding of the concept is highly essential. The mental tests depend on the good team work of a group of mental abilities acting together as one unit and intelligence is thought to be constituted of these abilities.

Abstract intelligence is measured by most of the verbal tests (and abstract intelligence is partly a product of heredity and partly of environment). Concrete intelligence is measured by performance tests and to some extent by the tests involving pictures rather than words. The present test measures abstract intelligence as well as concrete intelligence.

In framing the test items Spearman's principles of neogenesis have been kept in view. Later on in the factorial analysis of these tests only one general factor and the remaining specific factors have been found. No group factor has been discovered. Therefore the present research supports Spearman's two factor theory.
The factorial diversity of the abilities in adults is probably due to different life experiences and different kinds of school and vocational training.

As the present test is for the pupils of grades V to VII who are all students, 50% of the items are verbal. While preparing the test items, a great precaution was taken to avoid the effect of different specific abilities. The test is meant to measure only the "g" factor and to measure intelligence "A" as described by Hebb. It would be too much to align oneself to that school simply from the results of a comparatively small investigation like this.

2.3 THEORIES OF INTELLIGENCE

Apart from defining "intelligence", psychologists have been concerned to know the structure of intelligence. They have made analyses in an effort to determine its underlying factors. The purpose of these analyses has been to discover if possible the elements or components of intelligence, not only for a better theoretical understanding of this complex process but also to learn what might be the implications for the design and construction of mental tests.

It is not to be inferred, however, that the dynamics of intelligent activity can be adequately understood merely by enumerating and characterizing the components, whatever they might be. Whatever the components, they do not operate independently or in isolation. Understanding the dynamic aspects of mental activity requires some means of characterizing the organization of factors, their inter-relationships and their relation to motivational forces. Philosophers and psychologists developed various theories as regards to the nature of intelligence. The representative theories of intelligence are as follows:

2.3.1 Two-factor Theory

The first and for many years the most influential theory of trait organization based on a statistical analysis of test scores was the two factor theory. This attempt in analysing the nature of intelligence was made by English psychologist Charles
Spearman in the University of London where he was Professor of Psychology in 1904. He proposed that intellectual abilities were comprised of two factors, general ability or common ability, known as "g" factor and group of specific abilities known as "s" factor.

General mental ability (g) is a factor necessary for any kind of intellectual functioning. Characteristics of "g" are as follows:

(a) It is an universal inborn ability.

(b) It is general mental energy.

(c) It is constant in the sense that for any individual in respect of all the correlated abilities, it remains the same.

(d) The amount of "g" differs from individual to individual.

(e) It is used in every life activity.

(f) Greater the "g" in an individual, greater the success in life.

(g) It is merely a value of magnitude and not something concrete.

Performance on any task requires the operation of an additional "specific mental capability" (s) which is specific to that task. Characteristics of "s" are as follows:

(a) It is learnt and acquired in the environment.

(b) It varies from activity to activity in the same individual.

(c) Individuals differ in the amount of "s" ability.

This theory was the outcome of a deep and thorough observation of a mathematical data of co-efficients of correlation between different abilities. Although two types of factors, general and specific, are posited by this theory, it is only the single factor "g" that accounts for correlation. In contrast to other theories of trait relations, therefore it could be more precisely characterised as a single factor theory, although the original designation has persisted. Figure 2.1 illustrates the basis for correlations among tests according to this theory.
In this illustration, tests 1 and 2 would correlate highly with each other since each is highly saturated with "g" as shown by the shaded areas. The white area in each test represents specific and error variance. Test 3 would have low correlation with each of the other two tests since it contains very little "g".

FIGURE 2.1
CORRELATION MODEL UNDERLYING TWO FACTOR THEORY
He likened 'g' to general mental energy equivalent to physical energy, and therefore dominant. It is an innate, unchangeable factor. The 's' factor is energized by 'g' and is capable of modification under different environmental conditions such as formal education.

Spearman's theory although popularly called 'two factor' theory is basically a one factor theory or monarchic in structure because it depends on the existence of only one common factor. It is simple yet elegant presentation about the structure of human ability. Figure 2.2 presents the structure of ability in this connection.

A look at the figure 2.2 indicates that 'g' factor is present in all the five tests, while factor 's' is specific to a test - S₁ present in test 2, S₂ present in test 1, S₃ present in test 3, S₄ present in test 5 and S₅ present in test 4 only.

<table>
<thead>
<tr>
<th>Test</th>
<th>General 'g'</th>
<th>Specific Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S₁</td>
</tr>
<tr>
<td>1</td>
<td>+</td>
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<tr>
<td>2</td>
<td>+</td>
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<tr>
<td>3</td>
<td>+</td>
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<tr>
<td>4</td>
<td>+</td>
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<tr>
<td>5</td>
<td>+</td>
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</tr>
</tbody>
</table>

**FIGURE 2.2**

**STRUCTURE OF ABILITY**

From practical point of view of testing, this doctrine is very helpful because it gives one a method by which one can measure the intelligence of an individual. This theory has been a pioneer in advancing psychometric techniques and establishing the concept of general intelligence in psychological for half a century. It follows that aim of psychological testing should be to measure the amount of each individual's 'g'. Spearman proposed that a single test highly saturated with 'g' be substituted for the heterogeneous collection of items found in intelligence tests. He suggested that tests dealing with abstract relations are probably the best measures of 'g' and could be used for this purpose. Examples of tests constructed as measures of 'g' include Raven's Progressive Matrices and Cattell's Culture Fair Intelligence Test.
2.3.2 Holzinger's Bi-Factor Theory

Spearman and his adherents later on realised that those tests which do not satisfy the criterion of proportionality and which Spearman has termed distributors may be retained in the correlation matrix, if it is recognized that some of the tests may have a factor in common, in addition to the general factor that is common to all the tests. Holzinger's bi-factor theory which is a variation of Spearman's two factor method accepts a general factor and one or more group factors. The bi-factor may be represented schematically, as in Figure 2.3.

FIGURE 2.3
SCHEMATIC REPRESENTATION OF HOLZINGER'S BI-FACTOR THEORY
2.3.3 Sampling Theory

The two-factor theory has been criticised by some statistical psychologists, notably Thomson and Tryon. In 1916, G. H. Thomson first proposed his sampling theory which he refined in 1935 and still later in 1948. According to this theory, intellectual behaviour depends upon a large number of independent abilities, which enter into a wide variety of tasks. For example in figure 2.4, tests B, C and D have something in common. The double shading represent group factors and the unshaded areas represent specific factors. Test A has nothing in common with tests B, C and D. This theory explains the two factor theory and the hierarchical theory. This theory also explains why more complex subjects like English, Arithmetic or Latin possess more 'g'; for 'g' in them is not unitary but complex.

Thomson holds that the hierachical order and the zero tetrad differences can be explained by his sampling theory, according to which any activity such as a mental test calls upon a sample of bonds which the mind can form, and that some of these bonds are common to two tests and cause their correlation.
From his study Thomson ultimately said that he was more inclined towards Spearman's 'g' and to the later group factors. He thought that the theory of 'g' is, as it were, meaning the whole mind, and the tests were bringing out part of 'g'. He stated that Thurstone's work on second order factors had rehabilitated 'g'.

38
2.3.4 Multifactor Theory (Stimulus-Response Theory)

Thorndike thought that intelligence was neither a unitary quality nor a composite of two factors of Spearman or group factors as given by Thurstone, Burt and others. He, as a behaviourist, thought of mental acts as constituted of minute elements operating together. According to this theory intelligence is said to be constituted of a multitude of separate factors or elements, each one being a minute element of ability. Any intellectual activity is dependent upon a great number of these minute factors operating together. Therefore, if performances on any two intellectual activities are positively related, it is due to the number of common elements involved in the two activities.

If two types of mental activities A and B are more highly correlated than are A and C, the reason, according to the multifactor theory, would be that the first pair has more elements in common than does the second pair. In short, the degree of relationship of a pair of tasks is in direct proportion to the number of common elements involved in the tasks.

According to this theory, then, "there is really no such factor as "general intelligence"; there are only many highly specific acts, the number of such depending upon how refined a classification we might wish to make and are capable of making." 28

To his atomistic theory he adds, however, that certain mental activities have so many of their elements in common that it is useful to classify these tasks into separate groups to which special names are given; for example, verbal meaning, arithmetical reasoning, comprehension, visual perception of relationship and others. Consequently, in constructing a mental test, Thorndike found that his atomistic theory and multitude of minute elements of ability are of less practical significance than the conception that many of them operate together in any situation demanding intelligence, i.e. certain factors could be grouped together for purposes of measurement.
Thorndike's CAVD test designed to measure ability to deal with abstractions has tests of sentence completion (C), arithmetical reasoning (A), vocabulary (V), and the following of directions (D). It is not claimed by Thorndike that these four sets of items encompass the entire range of abstract intelligence. He contended that these measures of abstract intelligence were sufficient bases from which to estimate other aspects of abstract intelligence.

Thorndike later modified his view of highly particularised and independent abilities in favour of a theory of unique traits. This theory received the support of Kelley, Patterson, Hotgeljng and others. Kelley, for example, by means of statistical analysis of the intercorrelations between performances on many kinds of tests arrived at the conclusion that all the varying abilities of an individual can be accounted for on the basis of a relatively small number of independent traits or separate abilities that were completely unrelated to each other. These he called as orthogonal traits.

2.3.5 Group-factor Theory

Intermediate between the two factor of Spearman and multifactor theory of Thorndike is the group factor theory put forth by L. L. Thurstone. The then prevalent contemporary American view of trait organization recognised a number of moderately broad group factors, each of which may enter with different weights into different tests. For example, a verbal factor may have a large weight in a vocabulary test, a smaller weight in a verbal analogy test and a still smaller weight in an arithmetic reasoning test. Figure 2.5 illustrates the intercorrelations among five tests in terms of a multi-factor (group-factor) model.
The correlations of tests 1, 2 and 3 with each other result from their common loadings with the verbal factor (V). Similarly the correlation between tests 3 and 5 results from the spatial factor (S), and that between tests 4 and 5 from the number factor (N).

From the second basic theorem of factor analysis, we can also tell something about the relative magnitude of the intercorrelations. For example, test 3 will correlate highly with test 5 than with test 2, because the weights of the S factor in test 3 and test 5 (represented by the overlapping areas) are larger than the weights of the V factor in tests 2 and 3.

FIGURE 2.5
CORRELATION MODEL UNDERLYING GROUP FACTOR THEORIES

This theory has been advocated by L.L. Thurstone, an American engineer turned psychologist and his associates. His assumption was that certain mental operations have in common a primary factor (which is not essentially "g") which
gives them psychological and functional unity and which differentiates them from other mental operations. These mental operations constitute in themselves a group and the primary factor or the mental ability operating through that group or bunch of those operations was named as the "group factor" or the primary factor which is relatively independent of such other primary factors operating in certain other group or bunches of mental operations.

He objected to Spearman's emphasis on general intelligence. He felt that intelligence could be broken down into a number of primary abilities. To find these abilities, he applied the method of factor analysis to results from a large number of tests employing many different types of items. One set of items was for verbal comprehension, another for arithmetical computation and so on. He wished to find a more definitive way of grouping intelligence test items than the rather crude item-sorting used in the verbal and performance scales of the Stanford-Binet and Wechsler Tests.

After administering a large variety of test material to college students and to high school and eighth-grade pupils, he intercorrelated the scores of all the tests. Then he applied factor analysis to arrive at the basic factors. Those test items that best represented each of the discovered factors were used to form new tests; these tests were then given to another group of subjects and the intercorrelations reanalyzed. Thurstone and his collaborators concluded that six primary factors emerged clearly enough for identification and use in test design and construction. The six factors identified by Thurstone are as shown in Table : 2.2
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<thead>
<tr>
<th>Sr. No.</th>
<th>Factor</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>1</td>
<td>Number factor (N)</td>
<td>The ability to do numerical calculations rapidly and accurately.</td>
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<tr>
<td>2</td>
<td>Verbal factor (V)</td>
<td>The ability found in tests involving verbal comprehension. The ability to understand the meaning of words. Vocabulary tests represent this factor.</td>
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<tr>
<td>3</td>
<td>Space factor (S)</td>
<td>The ability involved in any tasks in which the subject manipulates an object imaginally in space. The ability to visualize space form relationships, as in recognizing the same figure presented in different orientations.</td>
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<tr>
<td>4</td>
<td>Word fluency factor (W)</td>
<td>The ability involved whenever the subject is asked to think of isolated words at a rapid rate. The ability to think of words rapidly, as in solving anagrams or thinking of words that rhyme.</td>
</tr>
<tr>
<td>5</td>
<td>Reasoning factor (R)</td>
<td>The ability found in tasks that require the subject to discover a rule or principle involved in series or groups of letters. Although it is believed both induction and deduction are involved, it seems that induction is more significant here.</td>
</tr>
<tr>
<td>6</td>
<td>Rote memory factor (M)</td>
<td>The ability to memorize quickly. The ability to recall verbal stimuli such as word pairs or sentences.</td>
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</table>

Later Thurstone added a new factor making it 7 - the perceptual ability (P). Still later he added 2 factors to his list making the total as nine, deduction reasoning (D) and inductive reasoning (I), apart from general reasoning (R).
Although primary mental abilities or factors were originally said to be functionally independent of each other, it was actually found that they were positively and significantly intercorrelated as shown in Table 2.3

**TABLE 2.3**

<table>
<thead>
<tr>
<th>INTECORRELATIONS OF SUBTESTS</th>
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<td>N</td>
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</tr>
<tr>
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<tr>
<td>M</td>
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<td>R</td>
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From Table 2.3 it is clear that the test constructors could not devise tests that would sample the primary mental abilities in pure form. This means that the primary and presumably independent factors are not the only factors at work in the mental activities required by the tests. There must be some other factor or factors to account for the common ground. Thurstone therefore concluded "that in addition to the primary abilities, there is a 'second-order general factor'. He also stated, 'if further studies of the primary mental abilities should reveal this general factor, it may sustain Spearman's intellective factor.'"29

Thurstone's hope of discovering the basic elements of intelligence through factor analysis was not fully realized for several reasons. His primary abilities are not completely independent. There are significant intercorrelations among them providing support to Spearman's idea of a 'g' factor.

The number of factors identified by factor analysis depends on the nature of the items chosen. The distinction between general, group and specific factors is
not so basic as it may first appear. If the number of variety of tests in a battery is small, a single general factor may account for all the correlations among them. But when the same tests are included in a larger battery with a more heterogeneous collection of tests, the original general factor may emerge as a group factor, common to some but not to all tests. Similarly a certain factor may be represented by only one test in the original battery, but may be shared by several tests in the larger battery. Such a factor would have been identified as a specific in the original battery, but would become a group factor in the more comprehensive battery.

Factorial research seems to have produced a bewildering multiplication of factors. Investigators using different test items have come up with a large number of cognitive factors. Guilford, for example, has suggested that there are atleast 180 unique intellectual abilities.

Attempts have been made to achieve a certain amount of order by cross-identifying factors. Even after these efforts at simplification and co-ordination, the number of factors remains large. Human behaviour is varied and complex, and perhaps it is unrealistic to expect a dozen or so factors to provide an adequate description of it. For specific purposes, however, one can choose appropriate factors with regard to both nature and breadth.

2.4 MODELS OF INTELLIGENCE

Any serious investigator in basic science or technology finds a good frame of reference very helpful. The one which is close to a scientific theory is the most useful to the investigator of a particular domain - for example, intelligence.

A good frame of reference to serve the investigator's purpose has three important specifications; it should be comprehensive, systematic and empirically based.

Human understanding of natural phenomena establishes the fact that there are regularities in nature. They offer the possibilities of establishing principles and scientific laws, which provide a short hand type for apprehending information. In the pursuit of further simplification, model building becomes possible. Model
building is theory construction. Piaget points out that there is growth in conceptions of what he calls seriation. By seriation he means the arrangement of items of information in linear order, each item related to the next in line in the same manner, as for example larger than, harder than, or more beautiful than. In the adult, particularly the educated adult, thinking in terms of abstract dimensions becomes more or less natural.

There are dimensional models, which are most widely applied in mathematics and the physical sciences. The second type of model is hierarchical model, in which there is a parallel development in the recognition of classes and of classes within classes. This type of model has been strongly advocated for an encompassing theory of intellectual abilities and other traits of personality.

The third type of model is named as morphological by the astronomer Zwickly. Basically this model is a cross classification of phenomena in interesting categories, rather than in categories within categories as in the hierarchical model. The most notorious example in science is the chemist's periodic table in which the chemical elements are arranged in rows and columns, each row and column representing a different category. It is also known as a logical matrix. The use of this type of model is advocated by Guilford.

A fourth type of model is known as operational type of model useful to conceive events in terms of interconnected series of transmission of information.

Current notions of intelligence have changed tremendously. Intelligence can not now be defined in monolithic terms like, "general intelligence" or "Spearman's 'g' factor". There are many more specialised types of abilities: verbal, numerical, mechanical, mathematical, spatial, perceptual, inductive reasoning, deductive reasoning, imagination, etc. And an individual may be quite high in one and comparatively lower in the other, though all these abilities tend to correlate positively and significantly. There is some divergence of views between the British and the American factor psychologists regarding the number of these abilities.
(factors) and their distinctiveness. The concept that intelligence is characterized by a general underlying ability plus certain task-specific abilities constitutes the basis of major theories of intelligence developed by British researchers. The hierarchical scheme has been proposed by a number of British psychologists including Burt and Vernon and by Humphreys and Cattell in America.

Quite distinct from the British theories of intelligence are those developed by American theorists. Whereas the British theories represent intelligence in terms of a general factor that can be broken down into more specific factors, the American theorists emphasize specific abilities that can be combined to form more general abilities. Thurstone developed factor-analytic techniques that first separate out specific or primary factors.

Raymond Cattell attempted a reproachement of the theories of Spearman and Thurstone. In an attempt to produce a general (g) factor, he combined Thurstone's primary factors to form secondary and higher order factors. Cattell found two major types of general factors and three minor ones, from his analysis. He labeled the two major factors as "fluid" and "crystallized" general intelligence (\(g_f\) and \(g_c\) respectively). Cattell argued that the fluid intelligence factor represents an individual's basic biological capacity and can be measured as perceptual ability. The other major factor, crystallized intelligence, represents the types of abilities required for most school activities which reflect experiential-educative-acculturative influences, and is measured by most general intelligence and achievement tests. Cattell labeled the minor general factors "gv", "gr" and "gs" for visual abilities, memory retrieval, and performance speed respectively. Cattell's initial theory has been extended by his co-worker Horn and others.

Humphreys also recommends a hierarchical model as a means of coping with the proliferation of factors. Rather than considering the first-order, narrower factors as primary, he suggests that each test constructor or user choose that level of the hierarchy that is most appropriate for her or his purposes. Humphreys recognises, however, that a single test may be classified into more than one
hierarchy, with reference to content, method and other facets. To measure any one facet, he proposes that the test be made "heterogeneous" with regard to all other facets. For example, if we are interested in the person's ability to solve analogies problems, we should use a test that includes verbal, numerical, pictorial and spatial analogies. If we wish to measure verbal ability, we should do so with a variety of item types, such as vocabulary, analogies and series completion. This procedure contrasts with that followed by Guilford who seeks separate factors (and tests) for each homogeneous cell in his three way classification.

2.4.1 Burt's Model:

As newly discovered factors increased in number, the need for arranging them into some kind of logical inter-relationships became a recognized problem. Cyril Burt, the British Psychologist, was one of the first to attempt at it. He suggested that intellectual abilities might be hierarchically organised. From his factor-analytic studies, he argued that comprehensive general factor could be used to represent all intellectual performance. This general factor could also be sub-divided into several group factors accounting for different broad classes of intellectual behaviour. These broad group factors according to Burt's conception can be further subdivided into narrower group factors, then down to numerous very specific factors.

Burt conceived of an ideal hierarchy within successive dichotomies, each sub-division of a higher factor to give immediately lower. He identified the various levels of bifurcation as relations at the highest level; associations at the second level; perception at the third level and sensation at the fourth. In fitting group factors into the model, however, Burt had to depart from strict dichotomization for many sub-categories contain more than two factors. At the association level, for example, he recognised a division into memory with a general retentiveness under which are group factors: visual, auditory, kinesthetic and verbal memory factor of fluency and originality. Other general association factors include verbal ability, language ability and arithmetical ability, under each of which are two or three sub-factors. Diagram illustrating Burt's Model is reproduced in Figure : 2.6.
FIGURE 2.6
BURT'S CONCEPTION OF AN IDEALISED HIERARCHICAL MODEL
2.4.2 Vernon's Model

Vernon elaborated Burt's hierarchical theory of intelligence. He, as a more recent worker in the field of intelligence testing, thought that British and American views differed about the number of primary abilities and about "g". Thurstone, Guilford and others broke the mind, according to Vernon, into a number of independent primary mental abilities with some overlapping (which showed a general or second order factor). Thurstone's work, according to Vernon, was carried out on homogeneous university students as the subjects of the study. At this age, due to the impact of cultural requirements, special abilities do get crystallized out of the general mental ability or "g". Whereas British studied whole range of school children and adults in whose case the correlation between quite different tests were termed to be high which pointed to the reasons of an underlying "g" and the specialised abilities were subsidiary group factors which were further composed of specific factors. As Vernon puts it, the lower the age of testees and lesser the effects of education and training, the better is the emergence of "g". But in each situation, the "g" factor, the group factors and the specific factors are there. In other words we can picture the mind as a kind of hierarchy or genealogical tree, where "g" is the most prominent mental ability, in the sense that it accounts for the greatest proportion of differences in abilities.

Diagram illustrating Vernon's application of this system is reproduced in Figure : 2.7.
FIGURE 2.1
VERNON'S MODEL OF HIERARCHICAL ORGANIZATION OF ABILITIES

FIGURE 2.7
VERNON'S MODEL OF HIERARCHICAL ORGANIZATION OF ABILITIES
At the top of the hierarchy, Vernon places Spearman's "g" factor. At the next level are two broad group factors, corresponding to verbal educational (v:ed) and to practical mechanical (k:m) aptitudes. These major factors may be further subdivided. The verbal-educational factor, for example, yields verbal and numerical sub-factors, among others. Similarly, the practical-mechanical information, spatial and psychomotor abilities. Still narrower subfactors can be identified by further analysis, for example of the verbal tasks. At the lowest level of the hierarchy are the specific factors.

In a later elaboration of the model, Vernon included certain more complex interrelations and cross contributions at the third level, especially in connection with educational and vocational achievement. At the second level a third group factor, the mathematical factor (M) also emerged through statistical analysis. A subject may score equally or differently on the three group factors, v:ed, k:m and M, as they are relatively independent.

Vernon's hierarchical scheme if inverted resembles a genealogical tree with "g" at the bottom, which tends to fall into three major group factors. The three group factors further seem to be broken down into more specific abilities.

In summary, the two major orientations in factor analytic theories of intelligence have been to emphasize a general factor or very specific factors. Whereas the British factor out a general factor first, and then consecutively factor major and minor group and specific factors, the Americans factor out specific abilities and consider general factor as of secondary importance. These differing theoretical orientations of the British and American researchers have strongly affected the composition of various types of intelligence tests. In particular, it has led to a predominance of general aptitude testing in the United Kingdom versus a predominance of differential aptitude testing in the United States.

2.4.3 Guilford's Structure of Intellect (The Cubic Model)

Guilford, the American Psychologist, rejects the idea of a general intelligence factor and also broad factor groups like Thurstone's primary abilities.
He believes that many aspects of intelligence tend to be ignored when items are lumped together to form tests. An item used as a test of verbal ability is distinguished from one that is non-verbal on the basis of its content-words as opposed to pictorial material. But what one does with the content of the test item will depend upon the nature of the task and may be relatively independent of the content. Suppose that a subject is shown pictures of a dozen different objects and is told that he will be asked to recall the names of the objects at some later time. Will this task involve verbal or pictorial ability? To be sure, pictures are presented, but most subjects will name the objects and then rehearse the names rather than try to memorize the pictures themselves.

Guilford maintains that intelligence test items should not be distinguished in terms of content alone, but also in terms of the operations performed upon the content and the product that results. He says that, "several facts based upon experiences in factor analysis of intellectual tests in the United States had cast doubt upon the applicability of a hierarchical structure. Almost no one reported finding a "g" factor, in fact, the tendency has been for each factor to be limited to a small number of tests in any analysis."  

The second consideration which he had given that "the absence of a "g" factor and the apparently comparable generality of all the factors do not support the hierarchical conception of their interrelationships."  

He thought that many factors have obviously parallel properties. According to him, "if one collects half a dozen verbal factors in one set and half a dozen non-verbal factors in another, it is clear that the factors in the two sets can be paired of in a meaningful manner. The psychological operation is the same in each pair, only the content of the test items is different."  

Guilford has attempted to bring order out of the welter of factors, with his theoretical "structure of the intellect". Structure of intellect, briefly written as "SI", is a model of intellect activity that was produced as a result of factor analytic
research conducted by J.P. Guilford and his associates in the Psychological Laboratory, at the University of Southern California in the U.S.A.

The "SI" model is an attempt to identify the nature of specific intellectual abilities by generating models of intelligence that postulate numerous intellectual skills. He suggests that since people obviously possess uneven constellations of mental abilities and the theories models, measures of intelligence ought to reflect these differences in a systematic fashion. The "SI" model postulates 180 specific components of intelligence based on 3 broad categories. According to him every mental process or intellectual activity has three dimensions, three basic parameters along which any possible intellectual behavior can take place-namely 'operation', 'product' and 'content'.

The three dimensions of the model represent the operation, content and product of a given kind of intellectual act.

1. **Operations**: What one does to the environment, basic psychological processes.

2. **Contents**: The nature of the information in the environment, the kind of material or content to which the person responds.

3. **Products**: The result of an operation upon the content, which produces the final overt response.

Each broad category has subcategories. 'SI' model consists of six types of mental operations, five types of content and six products.

As shown in Figure: 2.8, at present the maximum number of factors can be \(6 \times 5 \times 6 = 180\).

Operation is further subclassified into six components, namely (i) cognition, (ii) memory recording, (iii) memory retention, (iv) divergent thinking, (v) convergent thinking, and (vi) evaluation. Content is classified as (i) visual, (ii) auditory, (iii) symbolic, (iv) semantic, and (v) behavioural. Product comprises of (i) units,
(ii) classes, (iii) relations, (iv) systems, (v) transformation, and (vi) implications.

Each factor hypothesized or accounted for by the model is uniquely located and defined by specifying a category on each of the three dimensions. In this 'SI' model each factor has a trigram symbol, e.g. 'C.B.T.' would mean 'Cognition Behavioural Transformation' factors, and C.F.U. would stand for 'Cognition of a Figural Unit'. Customarily, the first part is taken from 'Operation' parameter, the second from 'contents' and the third from 'product'. Thus all the factors can be named as D.F.C., E.S.R. etc. Though some of the factors have not yet been identified practically, their properties can be written in advance. In 'SI' model, the factors are well defined and specific.
<table>
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<th>CONTENT</th>
<th>OPERATIONS</th>
<th>PRODUCT</th>
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**FIGURE 2.8**

**GUILFORD'S MODEL (STRUCTURE OF INTELLECT)**
Educational Significance of the 'SI' Model

Guilford's structure of intellect model has served several useful functions for educators. Some school districts have used the model to develop aspects of their curriculum, and some commercial companies have used the model as a guide in the construction of curricular materials.

This is the most comprehensive model taking into consideration all possible aspects of intellectual activity.

Two very significant educational implications of the SI model are:

1. In the present world, knowledge is expanding very fast, forcing specialization even at the earlier stages of the educative process. Special aspects of intellectual activity are involved in the different specialization processes both academic and professional. It is therefore needed "a prior" knowledge about the specific ability of each student to place him in the right line of specialization. SI model and analysis of the individual under its guidance can just pinpoint the individual's abilities and provide ones a secure base on which his future learning is to be based.

2. When some students with adequate intelligence fails to learn, corrective learning (also known as cognitive therapy) in that case first requires an accurate measure of his abilities, and some concrete steps for utilising his strengths and developing him where he is weak. Mere knowledge of IQ here is of little use. Only assessment made by SI model tests can provide here an academically acceptable method of dealing with the problems. This can be a great diagnostic use of this theory.

The international Encyclopedia of Education too states, "Guilford's SI model theory has led to the development of many educationally appropriate measures particularly in the area of creativity."
2.4.4 Sternberg's Triarchic theory of Human Intelligence

Robert Sternberg is a major figure in intelligence theory. He aims at nothing less than a kind of grand synthesis of ideas that for others are mutually contradictory. His three-part theory accommodates both the traditional view that intelligence is general, the same from one culture to another, and the counter-traditionalist view that environment—whether classroom or inner-city streets—shapes intelligence to different but equally valid ends. And, like the physicist who is comfortable with the knowledge that light is both a particle and a wave, Sternberg can look at intelligence as a set of components, "a wide array of cognitive and other skills", which are at the same time strongly unified by what he calls executive processes.

In the hot field of cognitive science, people in half a dozen different disciplines—psychology, artificial intelligence, philosophy, anthropology, linguistics and the neurosciences—are all trying to figure out what goes on in one's heads when one brings intelligence to bear on the behaviour. Or, to define the problem cognitively, one wants to know how one processes information. Models of the mind in action are essential if the computer scientists working on artificial intelligence are to develop the so-called fifth generation of smarter computers. Neuroscientists have been analysing the actual activity of the brain on the basic level of neuron and synapse and are preparing to test theories about the brain's operations in terms of larger processing units or circuits of neurons.

Cognitive psychologists are looking at behaviour how people actually solve problems and analyse the mental steps involved. But as Sternberg points out, the problems on which most psychological information-processing theories are based have largely been of the verbal analogy, sequence completion and spatial orientation type familiar to anyone who has come up through American schools.

In everyday life, though, as Sternberg writes in his recent book, 'Beyond I.Q.', "people no more go around solving analogies.... than they go around pressing buttons in response to lights or sounds".34
Sternberg says,

I started off as an information processing psychologist, and then I realized, well it's not that this stuff is wrong, it's only answering a subset of interesting questions. It does not deal with how business executives function in their jobs. It doesn't say anything about why my best student is the one with the relatively low Graduate Record Exam Scores, while people with high 700s, even 800s, sometimes come to Yale and flop.

In response to such questions, Sternberg's triarchic theory of intelligence evolved. This theory of human intelligence seeks to specify the loci of human intelligence and to specify how these loci operate in generating intelligent behaviour. It provides a somewhat broader conceptualization of intelligence than do most conventional theories. It is a theory of individuals and their relations to their internal world, their external worlds, and their experiences as mediators of the individual's internal and external world. The triarchic theory postulates the locus of intelligence to be in the individual, in behaviour and in the contexts of behaviour.

Structure of the Triarchic Theory

This theory seeks to understand intelligence in terms of three subtheories; a contextual subtheory that relates intelligence to the external environment of the individual, a componential theory that relates intelligence to the internal environment of the individual, and an experiential subtheory that applies to both the internal and external environments.

Behavior is intelligent to the extent that is (a) used in adaptation to, selection of, or shaping of one's environment; (b) responsive to a novel kind of task or situation or in the process of becoming automatized; and (c) the result of meta-componential, performance-componential, or knowledge-acquisitional functioning of the kind specified by the componential subtheory. The overall structure of the theory and subtheories is shown in Figure : 2.9.
TRIARCHIC THEORY OF INTELLIGENCE

COMPONENTIAL SUBTHEORY

1. METACOMPONENTS
2. PERFORMANCE COMPONENTS
3. KNOWLEDGE-ACQUISITION COMPONENTS

EXPERIENTIAL SUBTHEORY

1. ABILITY TO DEAL WITH NOVELTY
2. ABILITY TO AUTOMATIZE PROCESSING
3. SHAPING

CONTEXTUAL SUBTHEORY

1. ADAPTATION
2. SELECTION
3. SHAPING

COMPONENTIAL SUBTHEORY

Theory of Fluid Abilities
- Theory of Induction
  - Theory of Information Processing
- Theory of Deduction
  - Theory of Response Choice

Theory of Crystallized Abilities
- Theory of Knowledge Acquisition
  - Theories of Mediating Variables
    - Contextual Cues
  - Processes
- Theory of Real-time Processing
  - Theories of Representation Processing
FIGURE 2.9

STRUCTURE OF THE TRIARCHIC THEORY AND SUBTHEORIES OF HUMAN INTELLIGENCE
Sternberg sees three areas in which intelligence is exercised; the external (or contextual), the experiential and the internal. Intelligence is always mental activity, but each part of the theory considers it in relation to a different domain.

The context is, simply, the external environment in which intelligence functions, whether classroom, office or squash court. The same person may use his intelligence in each environment in a different way. Experience is the domain in which people face new situations, and in which intuition, insight and creativity - non-rational processes that simply don't come into the usual information processing picture - operate mental mechanisms, by which intelligence relates to the internal world of the individual, are brought to bear on intelligence through experience.

In short, Sternberg's triarchic theory is intended to get at the kind of intelligence that counts in real life - what Neisser calls general and Sternberg calls practical. Along with a number of other psychologists, many of whom disagree with him on almost everything else, Sternberg aims to change the way one thinks about intelligence. Ultimately, he hopes to revise intelligence testing to take practical intelligence into account.

2.4.5 Jean Piaget 36: A Biological Approach

Piaget is the most influential figure in child psychology today. Piaget was born in 1896 at Neuchatel in the French part of Switzerland. His father was a professor of medieval literature whose scholarly pursuits had an early impact on the young Jean. He early demonstrated an interest in science, publishing his first paper at the age of ten. His first scientific field was zoology, and by the age of 21, he had published twenty papers on molluscs. He was granted Ph.D. when he was 21. In his early twenties, Piaget became interested in psychological problems and worked for a while with Theodore Simon, the collaborator on the Binet scale of intelligence. Piaget was more interested in the responses children gave to the investigator's questions than in the test itself, and was especially fascinated by the incorrect answers and the way children arrived at them. During the same period, he also studied at Eugen Bleuler's
psychiatric clinic in Zurich, where he became acquainted with the "method clinic". It later proved very useful in interviewing children as to their processes of reasoning. In 1921, Piaget became the director of the Institute Jean Jacques Rousseau in Geneva. No other person has observed, analyzed and described child behavior and thought more comprehensively or incisively. Piaget was not as concerned about studying the static structure of intelligence at a point in time as he was about studying the systematic, dynamic evolution of intelligence or cognitive development over a period of time. According to developmental theorists, if one is to understand the nature of intelligence or cognitive abilities, it is very important to identify those processes that contribute to a change in development. What cognitive skills does an infant possess at birth, and how does the environment interact with the infant to produce qualitative and quantitative changes in development over a long period of time?

Piaget has arrived at the conception of intellectual development, after a lifetime of study. It reflects his basic interest in biology and epistemology. He postulates that human beings inherit two basic tendencies: "Organisation" (the tendency to systematize and organise processes into coherent systems) and "adaptation" (the tendency to adapt or adjust to the environment). As biological process of digestion transforms food into a form that the body can use, Piaget believes intellectual processes transform experiences into a form the child can use in dealing with new situations, and these processes must be kept in a state of balance, which they seek through the process of "equilibration" - a form of self regulation that permits the child to bring coherence and stability to his conception of the world and to make inconsistencies in experience comprehensible.

Organization and adaptation combine to produce cognitive "structures" or "schemata" that permit the child to differentiate between experiences and generalize from one experience to the another. Organization is illustrated by a child combining two separate skills, such as looking and grasping, into a more advanced skill-picking up something he is looking at. Adaptation occurs through two complementary processes: accommodation to the external environment which takes place as a result
of interacting with objects in a variety of ways, and assimilation of these new experiences, either by incorporating them into existing schemata or by developing new ones.

Piaget conceives of intelligence as the ability to adapt mentally to new situations. Viewed from a developmental perspective, the child is seen to evolve through increasing complex stages, namely, sensorimotor (0-2 years), pre-operational (2-7 years), concrete operations (7-11 years) and formal operations (11+ years).

2.5 ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is now recognised as one of the major scientific endeavours of the twentieth century. In the last decade, there has been an extraordinary growth in the practical application of AI to many fields: expert systems in industry, natural language understanding systems, robotics and so on. This growth has been fuelled by unprecedented support from American, European and Japanese governments.

AI is the science of designing computers to do things which would be considered intelligent if done by people. It can solve the problems in all the areas including education. Like all other new fields, Intelligent Computer Aided Instructions (ICAI) is both derivative and innovative. On the one hand, ICAI researchers bring with them or adopt theories and methodologies from associated disciplines such as psychology and computer science. On the other hand, ICAI is innovative in that it contributes ideas back to associated disciplines and also-as it must if it is to justify its own label - generates research guessflow of its own.

Intelligent machines are often referred so as self-organizing systems. In the strict sense of the words, such machines cannot exist since they would have to operate without external motivation of any kind. However, if external motivation is allowed, so that the system can be provided with criteria with which to evaluate its response, learning can occur.
Any attempt to reproduce human brain by extant technology is doomed to failure because of our inability to produce the intricate complexities and to simulate the detailed mechanism of any but the simplest neuron. It is quite unlikely that our knowledge encompasses all of the subtleties of interconnection required, and our models are certainly much more than first attempts at producing neuromimes. Even if suitable techniques are available, all we would achieve by a slavish modeling of the brain would be an extremely complicated logical device. Without the secret of life, we can not hope to construct an automation which would mimic the wisdom of Plato, the inquisitiveness of Newton, the inspiration of John Kennedy or the leadership of Mahatma Gandhi.

What we can hope to do, however, is to devise electronic systems which can operate in restricted areas performing those tasks which are currently delegated to humans, not because they require the intrinsic facilities possessed by a man, but because, heretofore, their performance has been beyond the capability of electronic systems. It is to be hoped that the application of these techniques will provide the keys to develop new approaches to the technology which will be required to support the continuing scientific revolution in the new millenium.

Very recently, Scientists at Bhabha Atomic Research Centre (BARC), Mumbai, have made use of AI to detect earthquakes. They have developed the techniques to detect very weak seismic signals which are otherwise difficult to detect. They have also designed two artificial neural networks (ANNs) which emulate the network of neurons in humans - for detecting and indentifying weak Seismic signals.

It is all to apparent that any major advance in the development of AI per se depends on the state of our knowledge of biological phenomena. But it can be confidently predicted that continued work in this field will yield useful and probably unexpected results, which will greatly affect the design of Philosophy and implementation of future electronic system.
Thus artificial intelligence has nothing to do with what we have understood "What human intelligence is" in this very chapter. And, intelligence tests are, therefore, going to exist in one form or another, under one name or another till mankind is to exist on the earth.


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