UNIT 1 THEORIES OF INTELLIGENCE (G AND S FACTORS AND THE MODEL OF JP DAS)

Structure

1.0 INTRODUCTION

Right from the dawn of civilisation man has often wondered about individual differences in abilities, yet it was not until the third quarter of the nineteenth century that efforts could be made about understanding its complex nature. Intelligence is a broad term that is employed by layman to denote the presence of such qualities as alertness, quickness of mind, level of one's academic success, status in an occupation, or the acquisition of an eminence in a particular field of endeavour and so on. In this unit we will deal with the nature and meaning of intelligence. We will also discuss some of the most important theoretical models of intelligence so as to understand its nature. We will begin with some definitions to bring home the point that even among the psychologists there is a lack of unanimity about this term. We will also briefly outline a historical perspective on individual differences and human abilities. Following this there will be a discussion on the Spearman's Two factor theory consisting of G and S factors, and a critical appraisal of the theory. We would also be dealing with Thorndike's theory of intelligence and PASS theory of intelligence put forward by JP Das and colleagues.

1.1 OBJECTIVES

After reading this unit, you will be able to:

- Define the term intelligence;
- Obtain a brief overview of individual differences and intelligence;

- Discuss Spearman's Two-Factor theory of intelligence;
- Make a critical appraisal of Two-Factor theory;
- Describe J. P. Das, Nagliery, and Kirby's PASS theory of intelligence; and
- Analyse the PASS theory.

1.2 THE NATURE OF INTELLIGENCE

Intelligence is hard to define. In the Indian systems of thought *buddhi* (intellect)—defined as *nischayatmikabuddhih* (decision maker) is described as an inner instrument (*antahkarana*), which possesses wisdom, prudence, emotion, societal values, and relations. In our common parlance when people speak of intelligence, they nod knowingly as if they all share a common definition. However, their understanding of the phenomenon of intelligence may widely vary. For some quickness of answering a question might reflect intelligence, while for others leading a successful life might be due to one's intelligence. Psychologists, too, differ in their definitions of intelligence. We all know what we mean when we use this term, but we find it terribly difficult to precisely define it.

1.2.1 Theoretical Definitions of Intelligence

Intelligence has been defined as the sum total of everything you know, as the ability to learn or profit from experience, as the ability to solve problems or as the ability to cope with the demands of the environment. Indeed there is nothing wrong with any of these definitions. The problem arises when we try to search for a definition that seems to say it all precisely. We have been using "intelligence" as a general label for so many cognitive abilities that it defies a specific definition. In 1921, a symposium was organised to define intelligence. Thirteen psychologists specialising in the area of intellectual assessment considered the definitional aspects of intelligence. The symposium proceedings, published in a special issue of the *Journal of Educational Psychology*, revealed that the experts had thirteen different views on the nature of intelligence. Some of the definitions given by experts are given below:

"…intelligence, that is to say, reasoning, judgment, memory, and the power of abstraction" (Binet 1890, cited in Sattler, 1988, p. 45)

"Intelligence is a general capacity of the individual consciously to adjust his thinking to new requirements" (Stern, 1914)

"An individual is intelligent in proportion as he is able to carry on abstract thinking" (Terman, 1921, p. 128)

"Intelligence is the capacity of the organism to adjust itself to an increasingly complex environment" (Spearman, 1927)

In 1986, Sternberg and Determan found that twenty-four prominent scholars had twenty-four different definitions of intelligence. Sternberg (1997) has attempted a comparison of the two surveys. He has remarked that in the 1921 survey, the elements that appeared most often in the definitions were "(a) higher level abilities (such as abstract reasoning, mental representation, problem solving, and decision making), (b) ability to learn, and (c) adaptation to meet the demands of the environment. In the 1986 survey, the most common elements were (a) higher

level abilities, (b) that which is valued by culture, and (c) executive process" (Sternberg, 1997, p.1030).

Snyderman and Rothman (1987) have presented responses of over 1,000 experts that belonged to different disciplines such as psychology, sociology, education, and genetics. Of the thirteen descriptions rated by the respondents, there was nearly unanimous agreement that abstract reasoning, the capacity to acquire knowledge, and problem solving ability were important elements of intelligence.

Per cent of respondents showing agreement on thirteen descriptor elements of intelligence given by Snyderman and Rothman (1987) are given below:

Table Showing Responses of Experts on Thirteen Elements of Intelligence

Descriptor	% of Respondents Checking as Important
Abstract thinking or reasoning	99.3
Problem solving ability	97.7
Capacity to acquire knowledge	96.0
General knowledge	88.3
Memory	80.5
Adaptation to one's environment	77.2
Mental speed	71.7
Linguistic competence	71.0
Mathematical competence	67.9
Creativity	59.6
Sensory acuity	24.4
Goal directedness	24.0
Achievement motivation	18.9

Source: Snyderman & Rothman (1987)

Most of the earlier definitions as well as recent ones include the elements that have been given above. We will mention a couple of recent definitions to support our statement.

"Intelligence, as a hypothetical construct, is the aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment" (Wechsler, 1944). More recently, Wechsler (1975) defined intelligence as "the capacity of an individual to understand the world about him and his resourcefulness to cope with its challenges" (p.139).

"…a human intellectual competence must entail a set of skills of problem solving—enabling the individual to resolve genuine problems or difficulties that he or she encounters, and, when appropriate, to create an effective product—and must also entail the potential for finding or creating problems—thereby laying the groundwork for the acquisition of new knowledge." (Gardner, 1983, pp. 60-61)

"Intelligence comprises the mental abilities necessary for adaptation to, as well as shaping and selection of, any environmental context." (Sternberg, 1997, p.1030)

A common element of several of the definitions that we have quoted is adaptation, the ability to modify one's behaviour to meet the environmental demands. A second common element is the ability to think abstractly using symbols. The ability to acquire new information or to learn through experience is similarly the third common element. However, it appears that the quest for a satisfactory definition of intelligence is an unending search.

1.2.2 Operational Definition of Intelligence

Observing the diversity of theoretical definitions in the 1921 survey, about which we discussed above, Boring (1923) operationally defined that "intelligence is what intelligence tests measure". You may notice that this operational definition sidesteps the thorny conceptual problem of coming to grips with the "true" nature of intelligence; it does not solve it. Nonetheless it does what operational definitions are supposed to do—it gives us a definition we can start working with. Most intelligence tests have been constructed with the assumption that intelligence is some kind of general attribute, more or less of which exists in everyone and which determines how an individual will be able to deal with a problem situation. However, this sort of assumption is not supported by recent theoretical models of intelligence that we will discuss next.

1.2.3 Historical Perspective on Individual Differences and Human Abilities

It is extremely surprising that in spite of tremendous advances in mathematical sciences by the year 1800, systematic studies of human abilities were not undertaken until third quarter of the nineteenth century. Impressed by Charles Darwin's *Origin of species*, his cousin Francis Galton devoted increasing attention toward measurement of anthropological and psychological phenomena. He coined the term *mental test* and invented the first psychological test methods to measure intelligence and ability. He founded the first test laboratory in London in 1882 at which visitors could take a battery of psychological tests on a fee-paying basis. Each visitor was tested on a variety of physical and sensory tests, including height, weight, breathing power, strength of pull, hearing, sight, and colour sense. Galton believed that psychological traits could also be inherited like physical characteristics. In statistics he made important contribution by developing and applying correlation method, which, at his guidance, was later continued by his student Karl Pearson, who eventually developed the product-moment correlation. Though his tests bear no resemblance to the advanced psychological tests, he definitely deserves to be credited with the title of Father of psychological testing and individual differences.

Alfred Binet's early work on human abilities resembled the work of Galton. Binet's work on intelligence testing took a practical turn during the opening years of the twentieth century, when he was commissioned by the French government to identify mentally deficient children in French schools. Faced with this problem, Binet, in collaboration with Theodore Simon, completed his first test in 1905. This test comprised a list of 30 problems concerning the child's ability to understand and reason with the objects in the environment. The problems ranged in level of difficulty and the test was tried on a sample of 50 children.

This was a very important step in the testing of intelligence.

In 1908, a revision was made in which items were arranged in terms of age levels. The highest age level that a child could perform successfully was called his *mental age*. Later, William Stern (1914) suggested that this be divided by the chronological age for each child, which multiplied by 100 became the intelligence quotient, the IQ, as it has come to be known. The influence of Binet on the measurement of intelligence can hardly be overstated. All subsequent work on the measurement of intelligence is modeled after Binet's test.

Self Assessment Questions

1) How does a layman define intelligence?

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2) What were the common factors that emerged regarding the definition of intelligence in the 1921 symposium of thirteen experts?

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3) On which elements there is maximal agreement in the Snyderman and Rothman data on 1000 experts?

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4) How will you operationally define the phenomenon of intelligence?

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5) Present a brief account of individual differences.

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1.3 SPEARMAN'S TWO-FACTOR THEORY OF INTELLIGENCE

Charles Spearman published an epoch-making study in 1904, which indeed proved to be the crucial step toward quantitative testing of theories, as opposed to simple quantification or measurement. He used the techniques of correlational analysis and factor analysis, both of which had been developed earlier by Karl Pearson, in relation to the scores obtained by groups of children on various intelligence tests. His historical significance can be seen in the development of the factor analytical method and in its explicit use for the first time. It is with regard to such importance that Guilford (1954, p. 472) has stated: "No single event in the history of mental testing has proved to be of such momentous importance as Spearman's proposal of his famous two-factor theory in 1904."

Spearman was critical of Binet and Simon's (1905) practice of assembling a hodgepodge of problems for testing intelligence without first testing for the presence of a general factor or without weighing the problems in terms of their loadings on the general factor. He was concerned to test the theory that the obtained intercorrelations between various tests of intelligence were due entirely to a general intellective factor "g". In addition to that, he also recognised specific factors, "s" factors, which were specific to particular tests. Eysenck (1972, pp. 1-2) has contended that "essentially his point was that under these conditions matrices of intercorrelations between tests should be of rank one; he did not use matrix algebra himself, but his formulas are the equivalent of more modern versions." Spearman (1927) elaborated and revised his work in "*The abilities of man*."

To understand his theory, let us assume that any correlation between two tests used by Spearman implies a factor common to both, plus two specific factors. Let the two tests be called *a* and *b*, the common factor "*g*", and the two specific factors *sa* and *sb*, as shown in the diagram drawn by Guilford (1953), which are reproduced below in Fig. 1.1.

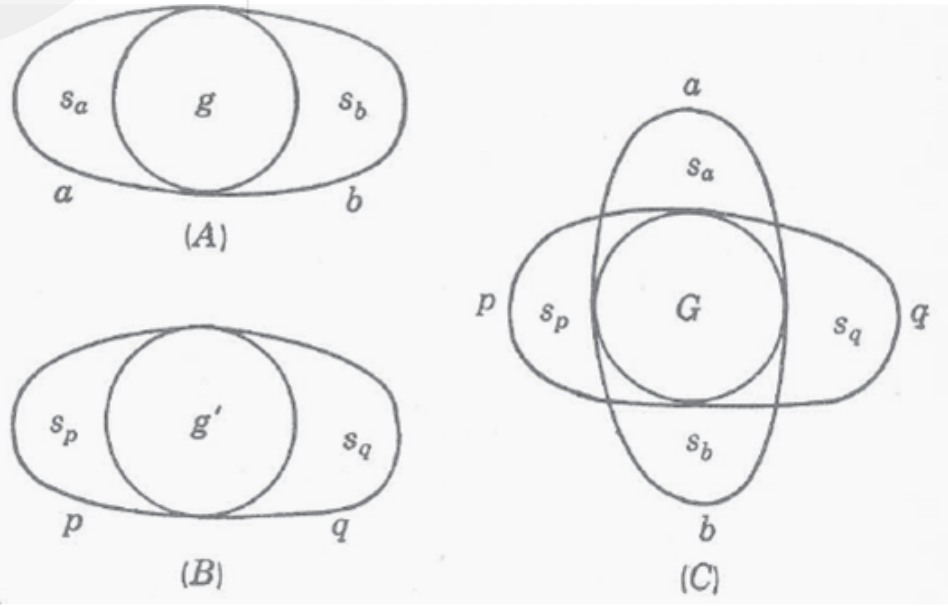

Fig.1.1: Graphical representation of Spearman's two factor theory
(*Source:* Guilford, 1953, p. 472)

In terms of the two-factor theory, we may regard that tests *a* and *b* are two measures of the common element "*g*", with the two remainders *sa* and *sb*. Similarly, let *p* and *q* be two other tests with *"g"* as the common element as shown in the Figure above. For some experiments, Spearman (1904) reported the correlations between "*g*" and "*g"* to approximate a value of 1.00. This meant that "*g*" and "*g"* were practically identical. Spearman believed that all intellectual activity contained some element or factor in common. This "*g*",or general factor, was postulated to be important in every mental act, although some acts were thought to depend upon it more than others. The difference between people in intelligence was a matter of how much "*g*"they possessed. Spearman called this general factor as "mental energy."

Spearmen's analysis of intelligence was actually an interpretation of certain observations by using the method of *tetrad difference*. The correlation matrix, which he used for finding the criterion of proportionality and for calculating the tetrad difference, is given below:

Table Showing Intercorrelations of Subtests Reported by Spearman (1927)

Subtests	1	2	3	4	5	6	7
Analogies	…	.50	.49	.55	.49	.45	.45
Completion	.50	…	.54	.47	.50	.38	.34
Understanding paragraphs	.49	.54	…	.49	.39	.44	.35
Opposites	.55	.47	.49	…	.41	.32	.35
Instructions	.49	.28	.39	.41	…	.32	.40
Resemblances	.45	.38	.44	.32	.32	…	.35
Inferences	.48	.34	.35	.35	.40	.35	…

***Source*:** Spearman (1927) *The abilities of man*. New York: Macmillan, (p.149)

Guilford (1953, pp. 473-474) has shown that for any correlation matrix the criterion of proportionality can be easily calculated, following which the tetrad difference between various subtests can also be found.

Let us understand what is tetrad difference? In recent years the quantity F, called the 'tetrad-difference', has become very important in psychological investigations as to the possible nature of the underlying causes of mental activities. If there are four such activities, and r_{13}, r_{24}, etc., the six correlation coefficients, (F is defined by the equation $F = r_{13}r_{24} - r_{14}r_{23}$. The value of F, in practice, approximates to zero.)

The tetrad difference thus in all cases comes to zero. The variation in measured intelligence that was not explainable in terms of this general factor or "*g*" was attributed by Spearman to specific factors or "*s*". There were many different specific factors. All intellectual tasks require some amount of "*g*." according to Spearman, the more highly the two functions were correlated, the more highly saturated they were with "*g*." Tests that are thought to have high "*g*" loadings involve abstract reasoning, comprehension, and problem solving.

Graphic illustration of "*g*" and "*s*" can be made following Guilford (1953, pp. 474-475), which is reproduced below (Fig.2). In this Figure "Spearman's "*g*" factor is shown as the large central circle and the specifics as small circles grouped

about *G*. Each ellipse stands for a mental test. The ellipses are permitted to overlap *G* to different extents in order to indicate the fact that some tests are more heavily "loaded" with *G* than others. The amount of correlation between any two tests is determined by the extent to which the two tests are loaded with *G*. Thus, tests *a* and *b* will have a relatively high correlation, since they have much in common in *G*. Tests *a* and *c* will be scarcely correlated at all, since both have small loadings with *G*." (Guilford, 1953, pp. 474-475)

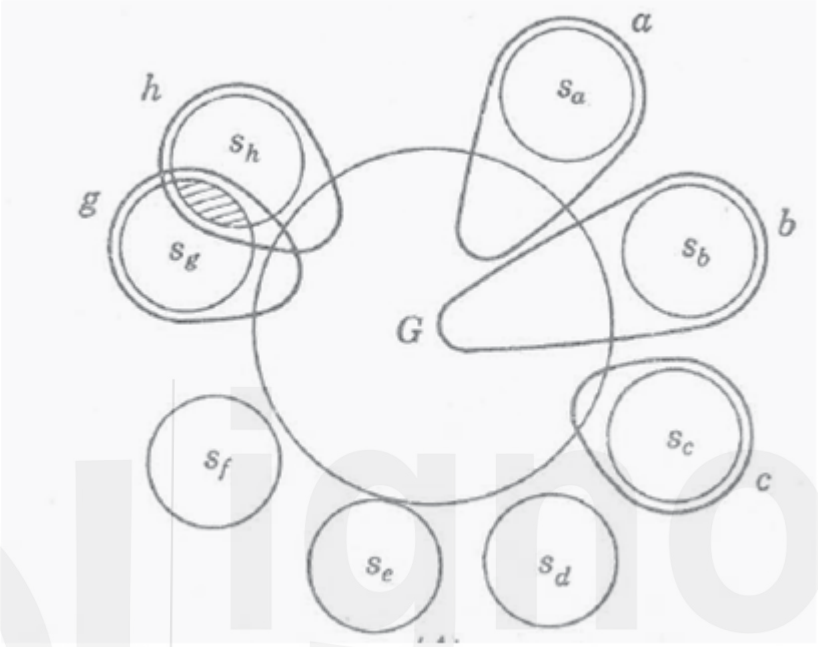

Fig. 1.2: Graphical representation of group factor in Spearman's two factor theory
(*Source:* Guilford, 1953, p. 475)

Inter correlation matrices prepared by Spearman and his students showed that some tests had something in common besides factor *G*. That meant that there were some correlations that were over and above that demanded by a single common factor *G*. Spearman at first attributed this to overlapping *s* factors. However, some tests may have a higher correlation than that attributable to *G* alone. Such an additional common factor became known as a *group factor*, which was found to play a role not only in two tests but also in a number of tests. "Among the group factors that Spearman and his associates came to recognise are verbal ability, numerical ability, and possible factors of mental speed, mechanical ability, attention, and imagination" (Guilford, 1953, p. 475).

Spearman's theories of intelligence are very stimulating and his contribution to the psychology of intelligence can be regarded important mainly for two major reasons.

1) First, he developed the mathematical models for studying "*g*" and for that purpose he laid the foundation of factor analysis. The logic and method of correlational analysis was afterward followed by other researchers for developing multi-factorial theories of intelligence.

2) Second major importance of Spearman's work is that it established a scholarly tradition in the investigation of human abilities.

According to Nunnally (1978, p. 508) "Spearman was concerned much more with *understanding* human abilities than with just measuring them. Spearman

had many interesting theories about *G*, its biological basis, the influence of culture, the interaction of *G* with manifestations of abilities in daily life, and the relation of *G* to speed, fatigue, and other variables."

1.3.1 Critical Appraisal of Two-Factor Theory

Several criticisms were levelled against formulation of the two-factor theory. One of the standard criticisms of the factor analytic approach is that it was purely psychometric and failed to provide a cognitive theory. However, Sternberg and Frensch (1990) have convincingly argued that this criticism was misplaced.

Spearman (1923) proposed that intelligence depended on a number of qualitative principles of cognition, for example "the presenting of any character together with any relation tends to evoke immediately the knowing of the correlative character" (p.91).

According to M. W. Eysenck (1990) Spearman also described "five quantitative principles of cognition, which are relevant to intelligence: conative control, fatigue, mental energy, primordial potencies, and retentivity" (p. 192).

Jensen (1998) confirmed the existence of "g" by the method of confirmatory factor analysis.

Carroll (1993) also noted the presence of "g" at Stratum III in her hierarchical factor analysis. We will now attempt a critical appraisal of the two-factor theory and see how it has helped in the development of newer models of intelligence.

1.3.1.1 Thorndike's Theory

One of the sharpest critics of Spearman's two-factor theory was E. L. Thorndike (1926), who believed that the inter correlations studied by Spearmen were too small to test the question of a common factor. He objected very strongly to the idea of the existence of a characteristic such as general intelligence. Instead of one kind of factor, he maintained that there are a large number of separate characteristics that make up intelligence.

He argued that instead of generality of intelligence, communality in the acts of people to perform intelligently needed to be looked into. According to Thorndike, the common element does not reside in the individual but in the nature of the tasks themselves. People differ in their ability to perform any specific act in terms of the level of difficulty they can manage. They also differ in the range or number of tasks they can or cannot perform.

For Thorndike, intelligence was more like a series of skills or talents and several or many tasks might call for the same kind of ability. According to him, the correlations between various tests are the result of the fact that the tests have features in common with each other even though they are called as measures of different aspects.

Thorndike's contention that there is no general intelligence but very specific acts has, however, does not hold water in view of the fact that some tasks have so many elements in common that it is desirable to classify them into groups such as arithmetical reasoning, visual perception, word meaning, analogy, etc.

Thorndike has classified intellectual activity into three broad types: (i) social intelligence, (ii) concrete intelligence, and (iii) abstract intelligence. However, this is a classification of the type of tasks and not an analysis of mental organisation itself. One can notice that the discrepancy of point of view between Spearman and Thorndike is basically a theoretical one and the types that interested Thorndike are essentially the same as the measures which Spearmen used in his correlation matrix.

1.3.1.2 Thomson's Theory

Among the other critics of Spearman, G. H. Thomson (1939) has argued that the inter correlations between tests are actually the result of common samplings of independent factors. As such if the tests incorporate many of these independent factors in common, i.e., the tests are all measuring some of the same factors, they will be highly inter correlated and it will appear that they are measuring one general factor "*g*."

Thomson has accordingly proposed a sampling theory, which maintains that every test samples a certain range of elementary abilities; some with a wide range and some with a narrow range. The degree of correlation between any two tests depends upon the number of units of ability that they have in common.

According to Thomson, abilities combine in such a way that their correlations approach Spearman hierarchical order. Thomson believed in a "general ability" like Spearman's "*g*", but according to him it was not a basic entity; it was rather a constant combination of the ability elements.

In like manner, the group factors are combinations of more limited collections of ability elements, while specific factors are composed of elements that restrict their appearance to single tests.

Guilford (1953) has refuted Thomson's contentions saying that "there seems to be little likelihood of demonstrating experimentally the existence of the elements hypothesized" (p.476).

1.3.1.3 Thurstone's Theory

L .L. Thurstone (1935) offered a new factor model in the nineteen thirties. Using improved techniques of statistical analysis, he came to vastly different conclusions from Spearman about nature of intelligence. Thurstone generalised Spearmen's methods and formulas, translated them into matrix algebra and carried out large-scale studies, using as many as fifty-seven tests on one group of subjects. On the basis of these studies he concluded that instead of Spearmen's "*g*" factor, seven primary abilities fitted the data much better.

Eysenck (1972) has given two reasons of this type of apparently conflicting findings. The first related to population sampled. Spearman had worked with random samples of the population (usually children), Thurstone worked only with students. The second related to the choice of tests: "Spearman has explicitly stated that tests should not be too similar to each other; if they were, then the "s" factors would overlap and cause additional correlations which would emerge as separate factors and disturb the unit rank of the matrix. Thurstone used groups of tests which were very similar, often almost identical, and consequently his study could certainly not be considered as a test of Spearman's hypothesis" (Eysenck, 1972, p. 2).

Thurstone later on recognised the force of these points and incorporated them in his subsequent work which enabled him to find "a hierarchical structure of intellect, with "g" at the top, and the "primary abilities" (whose inter correlations necessitated the postulation of "g") at a lower level; the actual tests used, whose inter correlations gave rise to the "primary abilities", would if course be at a lower level still" (Eysenck, 1972, p.2).

Self Assessment Questions

1) How did Spearman develop his two-factor theory?

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2) How an intercorrelation matrix is used for identifying the factors?

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3) What are the two main contributions of Spearman according to Nunnally?

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4) Present a critical appraisal of two-factor theory?.

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1.4 DAS, NAGLIERY AND KIRBY'S PASS THEORY

The theories of Spearman, Thorndike, Thomson, Thurstone that we discussed above, and other similar ones, are based on isolating factors after administering several intelligence tests over a large sample of subjects. They did not take into account how an input, e.g. a test item is received and processed and how a cognitive reorganisation takes place prior to giving a response. Das, Nagliery, and Kirby (1994) have developed a theory-based, multidimensional view of intelligence with constructs borrowed from contemporary research in neuropsychology, information processing and human cognition.

This theory has four components: Planning, Attention-Arousal, Simultaneous, and Successive (PASS) processing systems (see Fig.1.3).

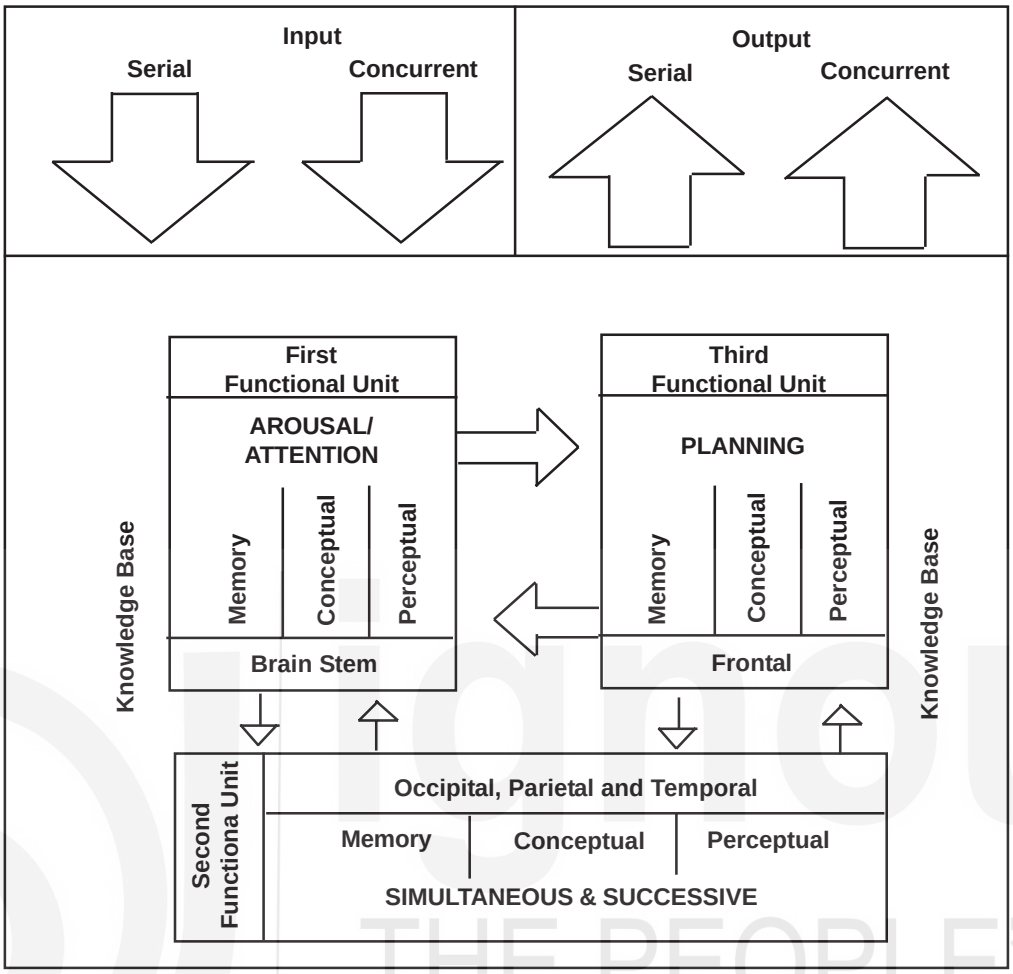

Fig. 1.3: Pictorial presentation of PASS model

(*Source:* Das, 2004; p.10)

Alexander R. Luria's (1966; 1973; 1980) pioneering researches in the fields of neuropsychology, information processing, and cognitive psychology have provided the theoretical foundation to the PASS theory. Luria divided human cognitive processes into three primary functional units.

i) Maintaining appropriate cortical arousal and attention to allow for adequate vigilance and discrimination between stimuli is the primary function of the first unit.

ii) The second unit is responsible for obtaining, elaborating upon, and storing information using successive and simultaneous processes.

iii) The third functional unit is responsible for programming as well as the regulation and control of mental activity (i.e., executive functioning). Planning, self-monitoring, and structuring of cognitive activities are provided by this functional unit.

To elaborate further, the first functional unit, attention-arousal, is located in the brain stem and reticular activating system. This unit provides the brain with the appropriate level of arousal or cortical tone and "directive and selective attention" (Luria, 1973, p. 273).

Attentional processes are engaged when a multidimensional stimulus array is presented to the subject, and the task requires selective attention to one dimension,

and the inhibition of response to other, often more salient stimuli. Luria stated that only under optimal conditions of arousal can the more complex forms of attention involving "selective recognition of a particular stimulus and inhibition of responses to irrelevant stimuli" occur (Luria, 1973, p.271). Moreover, Luria also maintains that only when sufficiently aroused and when attention is adequately focused can an individual utilise processes within the second and third functional units.

About the second functional unit, Luria described "two basic forms of integrative activity of the cerebral cortex" which are responsible for "receiving, analysing, and storing information" through the use of simultaneous and successive processing.

Simultaneous processing is associated with the occipital-parietal areas of the brain.

The essential aspect of simultaneous processing is the surveyability; that is, each element is related to every other element. Das (2004) has explained with the help of following example.

"To produce a diagram correctly when given the instruction, "draw a triangle above a square that is to the left of a circle under a cross," the relationships among the shapes must be correctly comprehended" (Das, 2004, p. 9).

Successive processing is associated with the fronto-temporal areas of the brain and involves the integration of stimuli into a specific serial order where each component is related to the next. That is, in successive synthesis, "each link integrated into a series can evoke only a particular chain of successive links following each other in serial order". For example, in language processing, successive processes involved with are decoding and producing syntax, and articulating speech.

The third functional unit is located in the prefrontal divisions of the frontal lobes of the brain (Luria, 1980). Luria stated that "the frontal lobes synthesize the information about the outside worlds . . . and are the means whereby the behaviour of the organism is regulated in conformity with the effect produced by its actions" (p.263).

Planning processes provide for the programming, regulation and verification of behaviour and are responsible for behaviours, such as asking questions, problem solving, and the capacity for self-monitoring. Other activities of the third functional unit include regulation of voluntary activity, impulse control, and various linguistic skills, such as spontaneous conversation. The third functional unit provides for the most complex aspects of human behaviour including personality and consciousness.

All four processes of the PASS theory have been operationally defined by Das, Nagliery and Kirby (1994). Planning processes are required when a test demands that the individual makes some decisions about how to solve a problem, execute an approach, activate attentional, simultaneous, and successive processes, monitor the effectiveness of the approach and modify it as needed.

Planning processes are involved when a person is asked to decide how to perform a test and is inhibited by the imposition of strict rules about how to perform. For

example, writing a composition involves generation of a plan, organisation of the ideas, control over what is presented when, examination of the product, and revisions to make the final result consistent with the intended goal.

Planning is clearly associated with the frontal lobes, especially the prefrontal cortex. It has connections with the rest of the brain as described before, including the parietal, temporal, and occipital lobes that are responsible for information coding (simultaneous and successive processing), as well as with sub cortical areas that determine the level of arousal and affective reactions to different conditions on the basis of past experiences.

Attention arousal is a complex process of the PASS theory. Arousal keeps the persons alert. It is associated with the activity of the brain stem and the lower part of the cerebral cortex. Attention on the other hand is associated with the frontal lobes and the lower portion of the cortex together.

Simultaneous processing is broadly associated with the occipital and the parietal lobes, while successive processing is associated with frontal temporal lobes

Knowledge base is an integral component of the PASS model and therefore all processes are embedded within this dimension. The base of knowledge included in the PASS model is intended to represent all information obtained from the cultural and social background of the individual, because this determines the form of mental activity. Children's use of language to analyse, generalise, and encode experience is a critical determinant of the base of knowledge, because mental processes cannot develop apart from the appropriate forms of social life.

The final component of the PASS model is output or action and behaviour. It is suggested that both simultaneous and successive processes must be used in the processing of cognitive tasks. Das (1998, p. 221) has thus explained its salient features: "The PASS theory of intelligence (1) has given us tests to measure intelligence as a set of cognitive processes, (2) discusses what the major processes are, and (3) guides us in the remediation of processing difficulties."

Cognition is a dynamic process that works within the context of the individual's knowledge base, responds to his experiences, and is subject to developmental variations When considering the measurement of cognitive processes, it must be noted that the effective processing is accomplished through the integration of knowledge with planning, attention, simultaneous, and successive processes as demanded by the particular task. Although these processes are interrelated and nonstop, they are not equally involved in all tasks. For that reason, cognitive assessment tasks for planning, attention, simultaneous, and successive processing were developed to adhere to PASS theory and predominantly require a specific cognitive process (Das, Nagliery, & Kirby, 1994).

Taking the lead of Das and by using the multivariate techniques of cluster analysis, Ronning (2004) developed ability/achievement normative taxonomies for reading and mathematics of children in the age group of 8 to 17 years. The core profiles that emerged provided important comparisons for evaluating individual profiles, as well as added to the information explaining common variability in the child population. The taxonomies werebased upon 711 children in the 8 to 17 year old portion of the standardisation sample ofthe Cognitive Assessment System (CAS) who were co-administered the Woodcock-Johnson Tests of Achievement–Revised

(WJ-R ACH). Ability/reading and ability/mathematics normative taxonomies were developed from the Planning, Attention, Simultaneous, and Successive scales of the Cognitive Assessment System (Das, Nagliery, & Kirby, 1994) in conjunction with four reading and three math WJ-RACH subscales. Eight reading and five math clusters were identified and described using demographics and overall ability and achievement levels, which enabled Ronning (2004) to develop intervention programme also.

1.4.1 Critical Appraisal of PASS Theory

The PASS theory has provided a novel approach to assess intelligence. It is cognitive in orientation and it bases its tests on neuropsychological theories of Luria. Of great importance of Das, Nagliery, and Kirby (1994) was to move away from conventional tests of intelligence and to provide a theory-based multidimensional view of intelligence that is built on contemporary research on human cognition. It has a practical utility also. Undoubtedly all tests of intelligence attempt at tapping cognitive aspects. However, most of them approximate to the underlying processing of informational input.

Another attribute of this theory is that it has developed a Cognitive Assessment System (CAS) test also, which offers a unique opportunity to examine the relative contribution of cognitive processes as a testee undergoes a testing scenario. CAS has four subscales, named after PASS, and the test items are specially designed to assess a testee's proficiency in each of them separately as well as collectively.

Self Assessment Questions

1) How are neuropsychological concepts of Luria incorporated in the PASS theory?

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2) Why planning has been given so much importance in PASS theory?

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3) What is the main contribution of knowledge base in PASS theory?

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4) Present a critical appraisal of PASS theory.

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1.5 LET US SUM UP

Intelligence is a concept that is so commonly referred by each one of us, but which is so difficult to define. There is a general agreement that thinking, reasoning, problem solving and decision making are all of relevance to intelligence. However, there is less agreement about the extent to which each component contributes to it. Much research on intelligence during the first half of the twentieth century was based upon the factor-analytic approach. This approach was pioneered by Spearman (1904;1923;1927) and his two-factor theory achieved the desired success in stimulating a whole host of researches in identifying the factors of intelligence. Eventually Spearman's work culminated in describing the hierarchical structure of intelligence. The research work that was directed at testing his theory extended the evidence that is consistent with the view that there is a general factor of intelligence (the "g"), together with a number of more specific factors. The various measures of intelligence, about which we shall study in a subsequent unit, have attested the ubiquitous presence of "g" as well.

It is a known fact that tests of intelligence, beginning with that of Binet and Simon (1905), have played an important input in predicting school success (or its absence) since the turn of the century. The various tests that were developed in criticism of Spearman, however, incorporated a number of similar characteristics. Intelligence test batteries differ in other ways, such as the theoretical underpinnings and appropriate uses of the test, as well as the types of questions utilised.We have already discussed the views of Thurstone who extended support to Spearman when methodology was followed as suggested by Spearman. Jensen (1998) and Carroll (1993) have found the presence of "g" in their factor analyses.

The PASS theory of Das, Nagliery and Kirby (1994) is an information processing theory, which has taken its inspiration from the pioneering neuropsychological and cognitive psychological researches of Alexander Luria (1966; 1973; 1980). Luria described human cognitive processes within the framework of three functional units. The function of the first unit is cortical arousal and attention; the second unit codes information using simultaneous and successive processes; and the third unit provides for planning, self-monitoring, and structuring of cognitive activities. Luria's work on the functional aspects of brain structures formed the basis of the PASS model and was used as a blueprint for defining the important components of human intellectual competence.

A Cognitive Assessment System (CAS) has also been developed by Das, Nagliery and Kirby (1994) and a number of researches on various aspects of human cognition have extended increasing support to the contentions of the proponents of this theory. The Cognitive Assessment System is an individualised assessment that may be used for a variety of purposes, including diagnosis, eligibility, determination of discrepancies, reevaluation, and instructional planning.

1.6 UNIT END QUESTIONS

1) How do general people explain intelligence?
2) What commonalities has Sternberg noted in the 1921 and 1986 surveys about definitions of intelligence?
3) Give a historical account of individual differences.
4) How far it is correct to state that Spearman was concerned much more with understanding intelligence than measuring it?
5) Discuss the salient features of two-factor theory.
6) Critically appraise Spearman's two-factor theory.
7) What constructs has PASS theory borrowed from the fields of neuropsychology and information processing?
8) Give operational definitions of all four processes of PASS theory.

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UNIT 2 MULTIPLE THEORIES OF INTELLIGENCE (GUILFORD, GARDNER AND STERNBERG)

Structure

2.0 INTRODUCTION

In Unit 1 we discussed a number of definitions of intelligence. We also noted that there is some sort of an agreement that reasoning, problem solving, thinking and other cognitive processes are all of relevance to intelligence. In other words it can be stated that intelligence comprises a variety of human cognitive activities such as learning from past experiences, adaptation to new situations, and thinking abstractly. In the first decade of the twentieth century, factor-analytic approach became popular and the debate about whether or not intelligence is a unitary construct still continues. Nowadays intelligence is conceived in terms of multiple abilities. In the present unit we will discuss three important theories of intelligence. First, we will explain the salient features of Guilford's Structure-of-Intellect

Theory, then we will turn our attention to highlight Howard Gardner's Theory of Multiple Intelligence, and finally we will discuss Sternberg's Triarchic Theory of intelligence.

2.1 OBJECTIVES

After reading this unit, you will be able to:

- Describe the contemporary approaches to intelligence;
- Elucidate Guilford's Structure-of-Intellect theory;
- Explain the multiple intelligences identified by Gardner;
- Differentiate between Guilford's structure-of-intellect theory and Gardner's theory of multiple intelligences;
- Define the triarchic theory of intelligence propounded by Sternberg; and
- Differentiate between Gardner's theory of multiple intelligences and Sternberg's triarchic theory of intelligence.

2.2 GUILFORD'S STRUCTURE-OF-INTELLECT THEORY

There are two distinct approaches to understand the nature of intelligence. The proponents of the first approach viewed intelligence as a single entity and developed their theories that take into account the biological reasons for intelligence. They view neural processing speed as the root of intelligence as such their theory has an effective causal explanation. The proponents of the second notion believed that intelligence is not a single or unitary ability, rather there are several intelligences. As for multiple intelligences, there are many theorists in that school of thought as well. Some of the theories presented by the proponents of multiple intelligences are excessive and have too many constructs to account for the explanation of intelligence. Guilford's Structure-of-Intellect (SOI) Model is such a multiple intelligences theory.

J. P. Guilford, was born on March 7, 1897 in Marquette, Nebraska. His interest in individual differences started from his childhood, when he observed the differences in ability among the members of his own family. As an undergraduate student at the University of Nebraska, he worked as an assistant in the psychology department. At Cornell University from 1919 to 1921, he studied under Edward Titchener and conducted intelligence testing on children. During his time at Cornell University, he also served as director of the university's psychological clinic. From 1927 to 1928, Guilford worked at the University of Kansas, after which he became Associate Professor at University of Nebraska, remaining there from 1928 to 1940. In 1940 he was appointed as psychology professor at the University of Southern California, where he stayed until 1967. Guilford retired from teaching in 1967, but continued to write and publish. He died on November 26, 1987.

Guilford believed that intelligence was not a monolithic, global attribute but a combination of multiple abilities, which were relatively independent. He applied factor analytic method to study these mental abilities. Building upon the views of Thurstone (1939), Guilford rejected Charles Spearman's view that intelligence

could be characterised by a single numerical parameter ("general intelligence factor" or *g*). He also rejected broad factor groups like that of Thurstone's primary abilities. According to him, intelligence consists of numerous intellectual abilities. By the 1950's, Guilford felt there needed to be a system developed to classify the new mental abilities being discovered.

In 1956, the first version of the Structure-of-Intellect (SOI) model was presented. The structure of intellect defines intelligence as a systematic collection of abilities or functions for processing different kinds of items of information in various ways. Originally the SOI model included four types of mental contents dimension (figural, symbolic, semantic, and behavioural), five types of operations dimension (cognition, memory, evaluation, convergent production and divergent production), and six types of products dimension (units, classes, relations, systems, transformations, and implications), thus resulting in 120 factors, with over 100 having been empirically verified. This model is represented as a cube with each of the three dimensions occupying one side. Many of the abilities are believed to be correlated with each other. The model also suggests where new abilities may be discovered based on existing abilities.

Subsequently, Guilford (1977) modified his model and divided *figural* factor of the content dimension into *visual* and *auditory* factors, thus making five types of the contents dimension, instead of the original four types. In the modified version the number of cells became 150 (5 contents × 5 Operations × 6 Products= 150 cells). The definition given by Guilford for each of these is too lengthy to present here; they will be described very briefly.

2.2.1 The Contents Dimension

This dimension includes the broad areas of information in which operations are applied. It has been divided into four categories.

- *Visual* - Information arising from stimulation on the retina in the form of an image.
- *Auditory* – Information arising from stimulation of the cochlea of the ear as image.
- *Symbolic* - Information perceived as symbols or signs that have no meaning by themselves; for example, Arabic numerals or the letters of an alphabet.
- *Semantic* - Information perceived in words or sentences, whether oral, written, or silently in one's mind.
- *Behavioural* – Information perceived as acts of an individual/ individuals.

2.2.2 The Operations Dimension

This consists of five kinds of operation or general intellectual processes:

- *Cognition* - The ability to understand, comprehend, discover, and become aware.
- *Memory* - The ability to memorise information.
- *Divergent Production* - The process of generating multiple solutions to a problem
- *Convergent Production* - The process of deducing a single solution to a problem.
- *Evaluation* - The process of judging whether an answer is accurate, consistent, or valid.

2.2.3 The Products Dimension

As the name suggests, this dimension contains results of applying particular operations to specific contents. There are six kinds of products, they are:

- *Unit* - Represents a single item of information.
- *Class* - A set of items that share some attributes.
- *Relation* - Represents a connection between items or variables; may be linked as opposites or in associations, sequences, or analogies.
- *System* - An organisation of items or networks with interacting parts.
- *Transformation* - Changes perspectives, conversions, or mutations to knowledge; such as reversing the order of letters in a word.
- *Implication* - Predictions, inferences, consequences, or anticipations of knowledge.

Some examples may provide a feel for the kinds of distinctions made in this model. Suppose a subject is given a long list of unrelated words to study and is asked to recall them later. The *content* of this scale is "semantic," since it involves words; the *operation* is "memory"; and the *product* is the recall of words as "units."

2.2.4 Evaluation

Guilford's Structure-of-Intellect theory is more complex than Thurstone's, which grew out of a massive analysis of a great many existing tests. Research from different fields, such as developmental psychology, artificial intelligence, and neurology, shows that the mind consists of several independent (albeit interdependent) modules or "intelligences." According to Eysenck (1972), Guilford "concentrated most of his studies on populations with a restricted range of intelligence, thus reducing the scope of "g"; and he has used orthogonal methods of rotation, thus ignoring the correlations between "simple structure" factors which would have emerged if he had used an oblique method of rotation...Of more practical importance is the criticism that Guilford's factors are so narrow and specialised that they have little value in prediction, as in educational and vocational guidance" (p. 3). In spite of these criticisms it is important to note that Guilford left a significant mark on research into intelligence. Many tests that are still used in modern intelligence testing were modified and developed under his guidance.

Self Assessment Questions

1) What do you understand by the term multiple intelligences?

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2) Elucidate Structure of Intellect Theory.

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3) What are the three dimensions of Guilford's theory of MI?

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4) Critically evaluate the construct-of-intellect theory of Guilford.

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2.3 GARDNER'S THEORY OF MULTIPLE INTELLIGENCES

Howard Gardner was born in Scranton, Pennsylvania in 1943. In order to make a career in law, he joined Harvard University. However, he was lucky enough to have Eric Erikson as a tutor. In Howard Gardner's words Erikson probably 'sealed' his ambition to be a scholar (1989). He entered Harvard's doctoral programme in 1966, and in the following year became part of the Project Zero research team on arts. Howard Gardner completed his PhD in 1971 (his dissertation was on style sensitivity in children). He remained at Harvard. Alongside his work with Project Zero, he was a lecturer (1971-1986) and then professor in education (1986-). His first major book, *The Shattered Mind* appeared in 1975 and some fifteen have followed.

Project Zero provided an environment in which Howard Gardner could begin to explore his interest in human cognition. He proceeded in a very different direction to the dominant discourses associated with Piaget and with psychometric testing. Project Zero developed as a major research centre for education and provided an intellectual home for a significant grouping of researchers. A key moment came with the establishment of the Project on Human Potential in the late 1970s (funded by Bernard van Leer Foundation) to 'assess the state of scientific knowledge concerning human potential and its realisation'.

In 1981 Gardner was awarded a MacArthur Prize Fellowship in support of Project Zero at Harvard University. An announcement of the award quoted Gardner as saying early in his career, that he had been a committed Piagetian, but as he pursued his own studies he came to view Piaget's theories as "too narrow a notion of how the human mind works." He noted further that he did not believe there was "one form of cognition which cuts across all human thinking. There are multiple intelligences with autonomous intelligence capacities." This statement heralded the writing of his book *Frames of Mind,* which was published in 1983.

Gardner (1983) claimed that most previous conceptualisations of intelligence had been too narrowly based. He argued that evidence from several different sources (e.g. cross-cultural accounts of cognition, studies of exceptional groups, psychometric data, and psychological training studies) pointed to the existence of several intelligences.

According to Gardner (1999), intelligence is much more than IQ because a high IQ in the absence of productivity does not equate to intelligence. In terms of his definition (1983): "Intelligence is a bio-psychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture". Consequently, instead of intelligence being a single entity described psychometrically with an IQ score, Gardner's definition views it as many things. He endeavored to define intelligence in a much broader way than did the psychometricians. To achieve this goal Gardner (1983; 1999) established several criteria for defining intelligence. In identifying capabilities to be considered for one of the "multiple intelligences" the construct under consideration had to meet eight criteria rather than resting on the results of a narrow psychometric approach.

To qualify as "intelligence" the particular capacity under study was considered from multiple perspectives consisting of eight specific criteria drawn from the biological sciences, logical analysis, developmental psychology, experimental psychology, and psychometrics. The criteria to consider "candidate intelligences" (Gardner, 1999) are:

- the potential for brain isolation by brain damage,
- its place in evolutionary history,
- the presence of core operations,
- susceptibility to encoding,
- a distinct developmental progression,
- the existence of idiot-savants, prodigies and other exceptional people,
- support from experimental psychology, and
- support from psychometric findings.

From the above eight criteria, Gardner initially formulated a list of seven intelligences. In 1999, he added naturalist intelligence as the eighth. He has also considered inclusion of existential intelligence as the ninth intelligence in his theory (Slavin, 2009). The first two have been typically valued in schools; the next three are usually associated with the arts; the next two are what Gardner called 'personal intelligences'; while the newly added final two are related to aesthetics and philosophical views of life (Gardner 1999). Each of these intelligences will now be briefly described.

2.3.1 Linguistic Intelligence

This intelligence includes the ability to effectively use language to express oneself rhetorically or poetically; and as a means to remember information. Writers, poets, lawyers and speakers are among those that Howard Gardner sees as having high linguistic intelligence. This area has to do with words, spoken or written. People with high verbal-linguistic intelligence display a facility with words and languages. They are typically good at reading, writing, telling stories and memorizing words along with dates. They tend to learn best by reading, taking notes, listening to lectures, and discussion and debate. Those with verbal-linguistic intelligence learn foreign languages very easily as they have high verbal memory and recall, and an ability to understand and manipulate syntax and structure. Careers that suit those with this intelligence include writers, lawyers, policemen, philosophers, journalists, politicians, poets, and teachers.

2.3.2 Logical-mathematical Intelligence

This intelligence consists of the capacity to analyse problems logically, carry out mathematical operations, and investigate issues scientifically. In Howard Gardner's words, it entails the ability to detect patterns, reason deductively and think logically. This intelligence is most often associated with scientific and mathematical thinking. This area has to do with logic, abstractions, reasoning, and numbers. While it is often assumed that those with this intelligence naturally excel in mathematics, chess, computer programming and other logical or numerical activities, a more accurate definition places less emphasis on traditional mathematical ability and more on reasoning capabilities, abstract patterns of recognition, scientific thinking and investigation, and the ability to perform complex calculations. It correlates strongly with traditional concepts of "intelligence" or IQ. Careers which suit those with this intelligence include scientists, physicists, mathematicians, logicians, engineers, doctors, economists and philosophers.

2.3.3 Musical Intelligence

This intelligence involves skill in the performance, composition, and appreciation of musical patterns. It encompasses the capacity to recognise and compose musical pitches, tones, and rhythms. According to Howard Gardner musical intelligence runs in an almost structural parallel to linguistic intelligence. This area has to do with sensitivity to sounds, rhythms, tones and music. People with a high musical intelligence normally have good pitch and may even have absolute pitch and are able to sing, play musical instruments, and compose music. Since there is a strong auditory component to this intelligence, those who are strongest in it may learn best via lecture. Language skills are typically highly developed in those whose base intelligence is musical. In addition, they will sometimes use songs or rhythms to learn. They have sensitivity to rhythm, pitch, meter, tone, melody or timbre. Careers that suit those with this intelligence include instrumentalists, singers, conductors, disc-jockeys, orators, writers and composers.

2.3.4 Bodily-kinesthetic Intelligence

It entails the potential of using one's whole body or parts of the body to solve problems. It is the ability to use mental abilities to coordinate bodily movements. In theory, people who have bodily-kinesthetic intelligence should learn better by involving muscular movement (e.g. getting up and moving around into the

learning experience), and are generally good at physical activities such as sports or dance. They may enjoy acting or performing, and in general they are good at building and making things. They often learn best by doing something physically, rather than by reading or hearing about it. Careers that suit those with this intelligence include: athletes, dancers, musicians, actors, surgeons, doctors, builders, police officers, and soldiers. Although these careers can be duplicated through virtual simulation, they will not produce the actual physical learning that is needed in this intelligence.

2.3.5 Spatial Intelligence

Spatial intelligence involves the potential for recognising and manipulating the patterns of both wide spaces such as those negotiated by pilots or navigators, and confined spaces such as those encountered by sculptors, architects or championship chess players. This area deals with spatial judgment and the ability to visualise with the mind's eye. Careers which suit those with this type of intelligence include artists, designers and architects. A spatial person is also good with puzzles.

2.3.6 Interpersonal Intelligence

This intelligence is concerned with the capacity to understand the intentions, motivations and desires of other people. It allows people to work effectively with others. Educators, sales people, religious and political leaders and counselors all need a well-developed interpersonal intelligence. This area has to do with interaction with others. In theory, people who have a high interpersonal intelligence tend to be extrovert, characterised by their sensitivity to others' moods, feelings, temperaments and motivations, and their ability to cooperate in order to work as part of a group. They communicate effectively and empathise easily with others, and may be either leaders or followers. They typically learn best by working with others and often enjoy discussion and debate. Careers that suit those with this intelligence include sales, politicians, managers, teachers, and social workers.

2.3.7 Intrapersonal Intelligence

This entails the capacity to understand oneself, to appreciate one's feelings, fears and motivations. In Howard Gardner's view it involves having an effective working model of ourselves, and to be able to use such information to regulate our lives. This area has to do with introspective and self-reflective capacities. People with intrapersonal intelligence are intuitive and typically introverted. They are skillful at deciphering their own feelings and motivations. This refers to having a deep understanding of the self; what are your strengths/ weaknesses, what makes you unique, you can predict your own reactions/ emotions. Careers which suit those with this intelligence include philosophers, psychologists, theologians, lawyers, and writers. People with intrapersonal intelligence also prefer to work alone.

2.3.8 Naturalistic Intelligence

This intelligence has to do with nature, nurturing and relating information to one's natural surroundings. Such a person demonstrates expertise in recognition and classification of the numerous species - the flora and fauna – of her or his environment. Careers which suit those with this intelligence include naturalists, farmers and gardeners.

2.3.9 Existential Intelligence

This is an ability to contemplate phenomena or questions beyond sensory data, such as the infinite and infinitesimal. Career which suits those with this intelligence include cosmologists, and philosophers.

According to Gardner (1983), each of these "intelligences" has a specific set of abilities that can be observed and measured. The first two forms of intelligence are typically the abilities that contribute to strong performance in traditional school environments and to producing high scores on most IQ measures or tests of achievement. The next three forms are very crucial for artists. The next two, viz., interpersonal and intrapersonal intelligences, are personal intelligences. Interpersonal intelligence indicates a person's ability to recognise the intentions, feelings and motivations of others. People who possess and develop this quality are likely to work well with others and may choose fields like sales, teaching, counselling or politics in order to use them when required. Intrapersonal intelligence is described as the ability to understand oneself and use that information to regulate one's own life. The last two intelligences are related to aesthetic feelings and philosophical issues. Gardner (1998) nominated three additional candidate intelligences: Naturalist, Spiritual and Existential intelligence and evaluated them in the context of the eight criteria he had established in his research and outlined earlier in this unit.

In *Frames of Mind*, Howard Gardner (1983) treated the personal intelligences 'as a piece'. Because of their close association in most cultures, they are often linked together. However, he still argues that it makes sense to think of two forms of personal intelligence. Gardner claimed that the seven intelligences rarely operate independently. They are used at the same time and tend to complement each other as people develop skills or solve problems.

According to Gardner, our schools as well as the society focus most of its attention on linguistic and logical-mathematical intelligence. Gardner emphasises that we should also place equal attention on individuals who show gifts in the other intelligences: the artists, architects, musicians, naturalists, designers, dancers, therapists, entrepreneurs, and others who enrich the world in which we live. Unfortunately, many children who have these gifts don't receive much reinforcement for them in their schools. Many of these kids, in fact, end up being labeled "learning disabled," attention deficit disorder" (ADD), or simply underachievers, when their unique ways of thinking and learning aren't addressed by a heavily linguistic or logical-mathematical classroom.

The theory of multiple intelligences proposes a major transformation in the way our schools are run. It suggests that teachers need to be trained to present their lessons in a wide variety of ways using music, cooperative learning, art activities, role play, multimedia, field trips, inner reflection, and much more. The theory of multiple intelligences also has strong implications for adult learning and development. Many adults find themselves in jobs that do not make optimal use of their most highly developed intelligences (for example, the highly bodily-kinesthetic individual who is stuck in a linguistic or logical desk-job when he or she would be much happier in a job where they could move around, such as a recreational leader, a forest ranger, or physical therapist).

The theory of multiple intelligences gives adults a whole new way to look at their lives, examining potentials that they left behind in their childhood (such as

a love for art or drama) but now have the opportunity to develop through courses, hobbies, or other programmes of self-development.

2.3.10 Evaluation

Howard Gardner's work around multiple intelligences has had a profound impact on thinking and practice in education. His theory has wide implications in the field of teaching and learning. For example, if you're teaching or learning about the law of supply and demand in economics, you might read about it (linguistic), study mathematical formulas that express it (logical-mathematical), examine a graphic chart that illustrates the principle (spatial) and then utilise all information into your teaching programme. One of the interesting characteristics of Gardner's theoretical approach is that several of the intelligences are not specifically cognitive in nature.

The concept of multiple intelligences can be quite useful in investigating specialised functions or clinical cases of mental dysfunctions. The major objection to the concept, however, is that an excessive importance is placed on the independence of these intelligences from one another and divides human beings on the basis of a new typology. In fact, the brain and indeed the human being act as a whole, and no one mental activity can be truly independent of another.

Gardner's theory has also been criticized by many psychologists on several grounds. The fundamental criticism of this theory is the belief by scholars that each of the seven multiple intelligences is in fact a cognitive style rather than a stand-alone construct (Morgan, 1996). Hunt (2001) criticised Gardner's theory on the ground that "theory of multiple intelligences cannot even be evaluated by the canons of science until it is made specific enough to generate measurement models" (p. 7). M. W. Eysenck (1990) remarked that "there are grounds for doubting that he has identified different intelligences rather than different abilities" (p. 193). As Sternberg and Frensch (1990) pointed out, it seems strange to describe someone who is tone deaf or physically uncoordinated as unintelligent. Other criticisms include the notion that the theory of multiple intelligences is not empirical, is incompatible with "g", heritability, and environmental influences, and broadens the construct of intelligence so widely as to render it meaningless.

However, we can conclude following the contentions of Das (1999), that "it can certainly be stated that the different types of intelligence included in Gardener's system of multiple intelligences is consistent with investigations of distinct talents and skills in individuals. We do study the nature of musical ability, strategies involved in playing chess, the thought processes of logicians and mathematicians, and early indicators of bring a cricket player, or a smooth, persuasive sales person" (p.222).

Self Assessment Questions

1) Describe Project Zero.

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2) What are the multiple intelligences identified by Gardner?

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3) Evaluate the importance of Gardner's approach in the explanation of intelligence.

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4) How is Gardner's theory differ from Guilford's construction of intellect theory?

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5) What is existential intelligence? Describe

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2.4 STERNBERG'S TRIARCHIC THEORY OF INTELLIGENCE

Robert Jeffrey Sternberg (born December 8, 1949), is an American psychologist and psychometrician. He received his B.A. degree from the Yale University and Ph.D. from the Stanford University under the supervision of Gordon Bower. He was Provost at Oklahoma State University. He was formerly the Dean of Arts and Sciences at Tufts University, IBM Professor of Psychology and Education at Yale University and the President of American Psychological Association. He holds ten honorary doctorates from one North American, one South American, and eight European universities, and additionally holds an honorary professorate at the University of Heidelberg in Germany. He is also a Distinguished Associate of The Psychometrics Centre at the University of Cambridge.

The triarchic theory of intelligence developed by Sternberg is "a comprehensive theory, because it takes into account social and contextual factors apart from human abilities" (Li, 1996). Sternberg (1985) felt that the theories that preceded him were not incorrect, but rather, incomplete. Consequently, his theory, like Gardner's, takes into account creative or musical intelligence. But as for the other six intelligences from Gardner's theory, Sternberg classified them into two different types of intelligences: analytic (or academic) and practical. These two types of intelligence differ and are defined as follows: Analytic problems tend to have been formulated by other people, be clearly defined, come with all information needed to solve them, have only a single right answer, which can be reached by only a single method, be disembodied from ordinary experience, and have little or no intrinsic interest. Practical problems tend to require problem recognition and formulation, be poorly defined, require information seeking, have various acceptable solutions, be embedded in and require prior everyday experience, and require motivation and personal involvement. (Neisser, *et al*., 1996). If an individual could solve one or the other of these types of problems well, then that individual would have a high analytic or practical intelligence, respectively. Also, there exists virtuosos, or individuals who are extremely talented in the fine arts, these people would have a high creative intelligence.

Sternberg's triarchic theory includes three facets or subtheories: (i) the componential subtheory which outlines the structures and mechanisms that underlie intelligent behaviour categorised as metacognitive, performance, or knowledge acquisition components, (ii) the experiential subtheory that proposes intelligent behaviour be interpreted along a continuum of experience from novel to highly familiar tasks/situations, (iii) the contextual subtheory which specifies that intelligent behaviour be defined by the socio-cultural context in which it takes place and involves adaptation to the environment, selection of better environments, and shaping of the present environment. According to Sternberg, a complete explanation of intelligence entails the interaction of these three subtheories. The componential subtheory specifies the potential set of mental processes that underlies behaviour (i.e., how the behaviour is generated) while the contextual subtheory relates intelligence to the external world in terms of what behaviours are intelligent and where. The experiential subtheory addresses the relationship between the behaviour in a given task/situation and the amount of experience of the individual in that task/situation.

Triarchic Theory

Componential Subtheory	Experiential Subtheory	Contextual Subtheory
Metacomponents	Novelty	Adaptation
Performance	Automation	Selection
Acquisition		Shaping
Acquisition		Shaping

2.4.1 Componential or Analytical Facet or Subtheory

Componential or analytical intelligence is the ability to complete academic, problem-solving tasks. These types of tasks usually present well-defined problems that have only a single correct answer. It is similar to the standard psychometric definition of intelligence e.g. as measured by academic problem solving, analogies

and puzzles, and corresponds to his earlier componential intelligence. Sternberg considers that this reflects how an individual relates to his internal world. According to Sternberg, analytical intelligence (academic problem-solving skills) is based on the joint operations of metacomponents and performance components and knowledge acquisition components of intelligence.

Metacomponents control, monitor and evaluate cognitive processing. These are the *executive* functions to order and organise performance and knowledge acquisition components. They are the higher-order processes that order and organise the performance components. They are used to analyse problems and pick a strategy for solving them. They decide what to do and the performance components actually do it.

Performance Components execute strategies assembled by the metacomponents. They are the basic operations involved in any cognitive act. They are the cognitive processes that enable us to encode stimuli, hold information in short-term memory, make calculations, perform mental calculations, mentally compare different stimuli, and retrieve information from long-term memory.

Knowledge acquisition components are the processes used in gaining and storing new knowledge – i.e. capacity for learning. The strategies you use to help memorize things exemplify the processes that fall into this category.

2.4.2 Experiential or Creative Facet or Subtheory

Experiential or creative intelligence is the ability to successfully deal with new and unusual situations by drawing on existing knowledge and skill. Individuals high in creative intelligence may give 'wrong' answers because they see things from a different perspective. Thus creative intelligence involves insights, synthesis and the ability to react to novel situations and stimuli. Sternberg considers it as experiential aspect of intelligence because it reflects how an individual connects the internal world to external reality. Sternberg considers the creative facet to comprise the ability that allows people to think creatively and that which allows people to adjust creatively and effectively to new situations. Sternberg believes that more intelligent individuals will also move from consciously learning in a novel situation to automating the new learning so that they can attend to other tasks. Thus experiential facet deals mainly with how well a task is performed with regard to how familiar it is.

Sternberg splits the role of experience into two parts: novelty and automation. A *novel* situation is one that you have never experienced before. People who are adept at managing a novel situation can take the task and find new ways of solving it that the majority of people would not notice (Sternberg, 1997). A process that has been *automated* has been performed multiple times and can now be done with little or no extra thought. Once a process is automatised, it can be run in parallel with the same or other processes. The problem with novelty and automation is that being skilled in one component does not ensure that you are skilled in the other also (Sternberg, 1997).

2.4.3 Contextual or Practical Facet or Subtheory

Sternberg's third subtheory of intelligence, called practical or contextual, "deals with the mental activity involved in attaining fit to context" (Sternberg, 1985). It is the ability to adapt to everyday life by drawing on existing knowledge and

skills. Practical intelligence enables an individual to understand what needs to be done in a specific setting and then do it. Through the three processes of adaptation, shaping, and selection, individuals create an ideal fit between themselves and their environment. This type of intelligence is often referred to as "street smarts."

Adaptation occurs when one makes a change within oneself in order to better adjust to one's surroundings (Sternberg, 1985). For example, when the weather changes and temperatures drop, people adapt by wearing extra layers of clothing to remain warm. *Shaping* occurs when one changes their environment to better suit one's needs (Sternberg, 1985). A teacher may invoke the new rule of raising hands to speak to ensure that the lesson is taught with least possible disruption. The process of *selection* is undertaken when a completely new alternate environment is found to replace the previous, unsatisfying environment to meet the individual's goals (Sternberg, 1985). For instance, immigrants leave their lives in their homeland countries where they endure economical and social hardships and go to other countries in search of a better and less strained life.

Sternberg's *triarchic theory of intelligence* contends that intelligent behaviour arises from a balance between analytical, creative and practical abilities, and that these abilities function collectively to allow individuals to achieve success within particular socio-cultural contexts (Sternberg, 1988; 1997; 1999). Analytical abilities enable the individual to evaluate, analyse, compare and contrast information. Creative abilities generate invention, discovery, and other creative endeavors. Practical abilities tie everything together by allowing individuals to apply what they have learned in the appropriate setting. To be successful in life the individual must make the best use of his or her analytical, creative and practical strengths, while at the same time compensating for weaknesses in any of these areas. This might involve working on improving weak areas to become better adapted to the needs of a particular environment, or choosing to work in an environment that values the individual's particular strengths. For example, a person with highly developed analytical and practical abilities, but with less well-developed creative abilities, might choose to work in a field that values technical expertise but does not require a great deal of imaginative thinking. Conversely, if the chosen career does value creative abilities, the individual can use his or her analytical strengths to come up with strategies for improving this weakness. Thus, a central feature of the triarchic theory of successful intelligence is adaptability-both within the individual and within the individual's socio-cultural context (Cianciolo & Sternberg, 2004).

2.4.4 Evaluation

The triarchic theory of intelligence provides a useful way of understanding human intelligence. It seems to capture important aspects of intelligence not captured by more conventional theories. It also differs from the theories of Howard Gardner, which emphasise nine independent multiple intelligences (such as linguistic and musical intelligence), and from the theory of emotional intelligence. The triarchic theory emphasises processes of intelligence, rather than domains of intelligence, as in Gardner's theory. It also views emotions as distinct from intelligence. Eventually, a theory may be proposed that integrates the best elements of all existing theories.

Triarchic theory has also been criticized by the psychologists. Gottfredson, (2003) criticized the unempirical nature of triarchic theory and argued that it is absurd to assert that traditional intelligence tests are not measuring practical intelligence when they show a moderate correlation with income, especially at middle age when individuals have had a chance to reach their maximum career potential. It is also claimed that what Sternberg calls practical intelligence is not a broad aspect of cognition at all but simply a specific set of skills people learn to cope with a specific environment (task specific knowledge). According to Das (2004), the major difficulty in Sternberg's theory is "in translating them to psychometric instruments for the measurement of cognitive abilities" (p. 12). As for the creative component of Sternberg's model, a study questions whether it's meaningful to treat creativity as a cognitive ability separate from analytical intelligence, but instead finds that creativity is simply the product of a high intelligence score.

Self Assessment Questions

1) Discuss Sternberg's triarchic theory of intelligence.

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2) Explain the three subtheories or facets of the triarchic theory of intelligence.

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3) How is triarchic theory of intelligence different from the construct-of-intellect theory?

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2.5 LET US SUM UP

According to Guilford intelligence is not one monolithic, global attribute but a combination of multiple abilities. He believed that there were many relatively independent mental ability factors. Guilford applied his factor analytic methodology to study these mental abilities. In 1956, the first version of the

Structure-of-Intellect (SOI) model was presented, which was subsequently revised by him in 1977. The SOI model includes a Content dimension, Products dimension, and Operations dimension. It is represented as a cube with each of the three dimensions occupying one side. Each ability is defined by a conjunction of the three categories, occupying one cell in the three-dimensional figure. There are five categories of content including visual, auditory, symbolic, semantic, and behavioural. Six categories exist in the products dimension including units, classes, relations, systems, transformation, and implications. The five kinds of operations include cognition, memory recording, memory retention, divergent production, convergent production, and evaluation. Guilford's SOI Theory is an open system such that it allows for newly discovered categories to be added in any of three directions. Many of the abilities are believed to be correlated with each other. The $5 \times 6 \times 5$ model of Guilford provides 150 possible abilities, with over 100 having been empirically verified. The model also suggests where new abilities may be discovered based on existing abilities.

The theory of multiple intelligences was developed in 1983 by Dr. Howard Gardner. It suggests that the traditional notion of intelligence, based on I.Q. testing, is far too limited. Instead, Gardner proposed nine different intelligences to account for a broader range of human potential in children and adults. Gardner's Theory of Multiple Intelligences proposes that people use seven (or nine) relatively autonomous intellectual capacities to approach problems and create products. These include linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, interpersonal, intrapersonal, naturalistic and existential intelligences. He suggests that "although they are not necessarily dependent on each other, these intelligences seldom operate in isolation. Every normal individual possesses varying degrees of each of these intelligences, but the ways in which intelligences combine and blend are as varied as the faces and the personalities of individuals."

Sternberg's triarchic theory of intelligence consists of three subtheories: (i) the componential subtheory, which outlines the structures and mechanisms that underlie intelligent behaviour categorised as metacognitive, performance, or knowledge acquisition components, (ii) the experiential subtheory that proposes intelligent behaviour be interpreted along a continuum of experience from novel to highly familiar tasks/situations, and (iii) the contextual subtheory, which specifies that intelligent behaviour be defined by the socio-cultural context in which it takes place and involves adaptation to the environment, selection of better environments, and shaping of the present environment. According to Sternberg, a complete explanation of intelligence entails the interaction of these three subtheories. The componential subtheory specifies the potential set of mental processes that underlie behaviour (i.e., how the behaviour is generated), while the contextual subtheory relates intelligence to the external world in terms of what behaviours are intelligent and where. The experiential subtheory addresses the relationship between the behaviour in a given task/situation and the amount of experience of the individual in that task/situation.

2.6 UNIT END QUESTIONS

1) How does theory of multiple intelligences differ from unitary theory of intelligence?

2) Highlight the important features of construct-of-intellect theory of Guilford.

3) Are the nine kinds of intelligence proposed by Gardner interrelated?

4) Evaluate the importance of Gardner's approach in the explanation of intelligence.

5) How is Gardner's theory different from Guilford's construct-of-intellect theory?

6) Critically evaluate Sternberg's triarchic theory of intelligence.

7) Explain the three subtheories or facets of triarchic theory of intelligence

8) How is triarchic theory of intelligence different from the construct-of-intellect theory?

2.7 GLOSSARY

Artificial intelligence : A branch of science that studies the capacity of computers to demonstrate performing that if, it were produced by human beings, would be described as showing the intelligence.

Contents dimension : In Guilford's three dimensional theory of intelligence construction of intellect includes five broad areas of information to which the human intellect applies the six operations.

Factor analysis : Mathematical procedure, involving correlations, for sorting trait terms or test responses into clusters or factors. It identifies items that are homogeneous or internally consistent.

Intelligence test : A standardised psychological test of general mental ability.

Intelligence quotient (IQ) : An index of individual's development determined by dividing his mental age by his chronological age and multiplying the result by 100.

Operations dimension : In Guilford's three dimensional theory of intelligence construction of intellect includes six operations or general intellectual processes.

Products dimension : In Guilford's three dimensional theory of intelligence construction of intellect product dimension contains results of applying particular operations to specific contents. The SI model includes six products, in increasing complexity:

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UNIT 3 MEASUREMENT OF INTELLIGENCE

Structure

3.0 INTRODUCTION

Need to measure intelligence arise to trap individual differences in general mental ability for a variety of purposes, such as academic classification, occupational counseling and personnel selection. Intelligence tests can be defined as a test to evaluate general level of cognitive functions and intellectual ability. In this unit we will discuss theoretical background and evolution of intelligence tests. We will also present an account of some of the widely used intelligence tests. The unit will be concluded by highlighting the issues related to intelligence testing.

3.1 OBJECTIVES

After reading this unit, you will be able to:

- Define intelligence tests;
- Describe the concepts of IQ and deviation IQ;
- Explain the theoretical background of measurement of intelligence;
- Elucidate the history of intelligence tests;
- Explain the types of intelligence tests; and
- Describe various widely used intelligence tests.

3.2 THEORETICAL BACKGROUND OF MEASUREMENT OF INTELLIGENCE

Intelligence tests differ a lot in the content and the way of measurement. These differences arrive from the theoretical background they follow and also from defining intelligence. Therefore, before discussing specific intelligence tests we must understand the theoretical background they follow.

3.2.1 General Factor Theories

On the basis of factor analysis of scores on a number of tests, general factor theories claim that intelligence is basically a general intellectual capacity which is common for a number or all of activities. One of such theories was proposed by Charles Spearman (1904) who claimed that there is a *general* or *g-factor* which is essentially common in all the intellectual activities. Spearman suggested that two tests truly measuring *g* would account for high positive correlation. In a revision of the theory, he proposed a number of *specific* or *s-factors* required for specific activities. Tests measuring distinct *s-factors* should account for zero-correlation.

Jensen (1998) further advocated this viewpoint by arguing that *g-factor* is manifested in behaviour in a number of ways and can be tested by almost unlimited variety of conceptually independent items. Therefore, a number of distinct tests can be constructed to measure *g-factor* with completely different form and content of the items. However, Jensen's idea that *g* is largely inherited and rarely influenced by the environment was highly controversial and criticized.

Binet and Simon (1916) also conceptualised intelligence as a general intellectual capacity. But he differed from Spearman and Jensen and proposed that this can be measured by a variety of test items measuring several discrete abilities. An integrated score, termed as intelligence quotient (IQ), on all of these ability tests would account a true measurement of intelligence. According to Binet a general intellectual capacity consists of the abilities of (a) abstract reasoning (b) comprehension (c) clear direction of thought (d) purposeful thinking and (e) self-corrective judgment.

3.2.2 Multi-factor Theories

Contrary to Spearman, multi-factor theories neglect the existence of *g-factor* and state that intelligence is not an expression of innumerable highly specific

factors, nor is it the expression primarily of a general factor that pervades all mental activities. Such theories describe intelligence on the basis of groups of traits or factors.

3.2.2.1 Thurstone's Primary Mental Abilities/Group Factor Theory

The analysis of interpretation of Spearman's and others' general factor theories led Thurstone to conclude that 'certain' mental operations have in common a 'primary' factor that gives them psychological and functional unity and that differentiates them from other mental operations. These mental operations then constitute a group. A second group of mental operation has its own unifying primary factor, and so on. In other words, there are a number of groups of mental abilities, each of which has its own primary factor, giving the group a functional unity and cohesiveness. Each of these primary factors is said to be relatively independent of the others.

Thurstone has given the following seven primary factors:

i) The Number Factor (N) refers to the ability to do rapid and accurate numerical calculations.

ii) The Verbal Factor (V) refers to the ability of verbal comprehension.

iii) The Space Factor (S) is involved in a task requiring manipulation of the imaginary objects in space.

iv) Memory (M) involves ability to memorize quickly.

v) Word Fluency (W) refers to the ability to think of isolated words at a rapid rate.

vi) Reasoning (R) refers to the ability to discover a rule or principle involved in a series or groups of letters.

vii) Perceptual Speed (P) is the ability to note visual details rapidly.

Based on these factors Thurstone constructed a new test of intelligence known as "Test of Primary Mental Abilities (PMA)."

3.2.2.2 Guilford's Model of Structure of Intellect

Guilford (1967) proposed a three dimensional structure of intellect model. According to Guilford every intellectual task can be classified according to its (1) content, (2) the mental operation involved and (3) the product resulting from the operation. He further classified content into five categories, namely, visual, auditory, symbolic, semantic and behavioural. He classified operations into five categories, namely, cognition, memory retention, memory recording, Divergent production, Convergent production and evaluation. He classified products into six categories, namely, units, classes, relations, systems, transformations and implications.

3.2.2.3 Gardener's Theory of Multiple Intelligences

Howard Gardner in his book "Frames of Mind: The Theory of Multiple Intelligence" (1983), puts forth a new and different view of human intellectual competencies. He argues boldly and cogently that we are all born with potential to develop a multiplicity of Intelligence, most of which have been overlooked in our testing society, and all of which can be drawn upon to make us competent individuals. The multiple intelligence theory states that people possess eight types

of intelligence: (i) Linguistic, (ii) Logical, (iii) Spatial, (iv) Musical, (v) Motor ability, (vi) Interpersonal, (vii) Intrapersonal and (viii) Naturalistic intelligence.

3.2.2.4 Sternberg's Triarchic Theory

Psychologist Robert Sternberg (1985) has constructed a three-pronged or triarchic theory of intelligence. The Three types are:

i) Analytical Intelligence is what we generally think of as academic ability. It enables us to solve problems and to acquire new knowledge. Problem-solving skill includes encoding information, combining and comparing pieces of information and generating a solution.

ii) Creative Intelligence is defined by the abilities to cope with novel situations and to profit from experience. The ability to quickly relate novel situations to familiar situations (that is, to perceive similarities and differences) fosters adaptation. Moreover, as a result of experience, we also become able to solve problems more rapidly.

iii) Practical Intelligence enables people to adapt to the demands of their environment. For example, keeping a job by adapting one's behaviour to the employer's requirements is adaptive. But if the employer is making unreasonable demands, reshaping the environment (by changing the employer's attitudes) or selecting an alternate environment (by finding a more suitable job) is also adaptive.

3.2.2.5 Vernon's Hierarchical Theory

Vernon's description of different levels of intelligence may fill the gaps between two extreme theories, the two-factor theory of Spearman, which did not allow for the existence of group factors, and the multiple-factor theory of Turstone, which did not allow a "g" factor. Intelligence can be described as comprising abilities at varying levels of generality:

i) The highest level: "g" (general intelligence) factor with the largest source of variance between individuals. (Spearman)

ii) The next level: major group factors such as verbal-numerical-educational (v.ed) and practical-mechanical-spatial-physical (k.m.) ability.

iii) The next level: minor group factors are divided from major group factors.

iv) The bottom level: "s"(specific) factor. (Spearmen)

Beginning in 1969, Vernon became increasingly involved in studying the contributions of environmental and genetic factors to intellectual development. Vernon continued to analyse the effects of genes and the environment on both individual and group difference in intelligence. He concludes that individual difference in intelligence are approximately 60 percent attributable to genetic factors, and that there is some evidence implicating genes in racial group differences in average levels of mental ability.

3.3 HISTORY OF MEASUREMENT OF INTELLIGENCE

At the time of early development of discipline psychologists were much more interested in searching of generalised principles of human behaviour and

subsequently formulating universal theories. Measurement of individual differences received attention very late in the nineteenth century.

3.3.1 Galton and Cattell

The first institutional effort to measure individual differences came from the British biologist Sir Francis Galton who administered simple tests of visual discrimination, determining highest audible pitch and kinesthetic discrimination. He thought that intelligence could be measured by the tests of sensory discrimination. He believed that the ability to discriminate among heat, cold and pain could discriminate the intelligent persons from the mentally retarded ones.

The term 'mental test' was used first time in the psychological literature by the American psychologist James McKeen Cattell in 1890. He described a number of tests to measure intellectual level of persons which included measures of muscular strength, speed of movement, sensitivity to pain, keenness of vision and of hearing, weight discrimination, reaction time, memory etc.

3.3.2 Contribution of Alfred Binet

Alfred Binet (1857-1911) set out to develop a series of tasks designed to measure individual differences on the request of the French government due to the need for a reliable diagnostic system to identify children with mental retardation. The differences that he intended to delineate included a number of complex mental facilities, such as memory, imagery, imagination, attention, comprehension, aesthetic sentiment, moral sentiment, muscular strength, motor ability, and hand-eye coordination. Together with physician Theodore Simon, Binet created the Binet-Simon scale, which was published in 1905.

The 1905 Binet-Simon scale differed greatly from the scale that we use today. The original scale consisted of 30 pass/fail items. The tasks were also different from today's items and required a combination of mental and physical strategies to complete each task.

The major breakthrough of the Binet-Simon scale was the complexity of the tasks and the breadth of mental abilities measured. Furthermore, intelligence was finally able to be measured during a clinical interview, as opposed to in laboratories or by using physical measurements.

Although the Binet-Simon scale is quite antiquated with regard to today's intelligence scale standards, many current day innovations were derived from this scale. The concepts of strict administration, age-graded norms, and a rank order of items ranging from least to most difficult, are but a few. Furthermore, the inclusion of age-graded norms provided for the first estimate of mental age.

The first revision of the Binet scale was in 1908; however, the majority of the scale was left unchanged. By 1911, the scale was in its second revision and the age range had been extended through adulthood, as opposed to its previous use for the diagnosis of mental retardation in children. With the inclusion of adults, the scales needed to be rebalanced, which Binet did by including five items for each age level.

The abilities targeted by the 1911 edition were language, auditory processing, visual processing, learning and memory, and problem solving. By 1912, Lewis

M. Terman of Stanford University began revisions on the 1911 Binet scale which was published in 1916 and was entitled the *Stanford-Binet Intelligence Scale*.

The advantages that the Stanford-Binet had over other intelligence scales of the time were many. The first, and seemingly most simplistic, was that the 1916 version was the most comprehensive revision of Binet's original scale. The second, and perhaps the most important, was that the standardisation procedure used by Terman was the most rigorous of the time. The third advantage was the inclusion of an extensive manual, both for administration of the test as well as for use as a teaching aide for understanding the test.

3.3.3 The Concept of IQ

The most important development in the area of intelligence testing was adaptation of Stern's (1912) concept of an intelligence quotient in the Stanford-Binet Intelligence Scale. Stern put forth the notion that to derive an intelligence quotient (IQ) and Terman incorporated this concept into the 1916 version of Stanford-Binet Scale. To obtain the IQ a person's mental age is divided by his/her chronological or real age. This product is further multiplied by hundred to avoid decimal fractions.

$$IQ = \frac{\text{Mental Age}}{\text{Chronological Age}} \times 100$$

3.3.4 World War I and Army Personnel Selection

During World War I in 1917 a committee of American Psychological Association, under leadership of Robert M. Yerkes, prescribed the use of intelligence tests for rapid classification of army personnel. In view of this, American Army psychologists developed two tests: (i) Army Alpha and (ii) Army Beta. Both the tests were group tests in which the first was a language test, while the second was a non-language-performance test.

Self Assessment Questions

1) Describe the contributions of Galton and Cattell in the development of measurement of individual differences.

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2) Explain first Simon-Binet Test and its improvement over earlier tests.

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3) Illustrate the concept of IQ.

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3.4 MAJOR INTELLIGENCE TESTS

Intelligence tests are classified on several bases.

i) Individual and Group tests (Target)

ii) Verbal and Non verbal tests

Individual and Group Tests

The first of these classification, individual and group tests, is based on their administration. An individual test is one that can be administered only at one person at a time (Simon-Binet). During World War I rapid and mass classification of army personnel was required and such tests could not fulfil these needs. Therefore, group intelligence tests were developed which could be administered on a group of individuals at one go (Army Alpha and Army Beta).

Verbal / non verbal tests

Another classification of intelligence tests based on the form and content of the test items is verbal/paper-pencil tests and non-verbal/performance tests. Verbal tests use written language for its items and therefore, require the examinees to be literate. Items of performance tests do not use language at all and are manipulative in form and nature. Examinees are required to manipulate the items in a particular and desired manner. Hence, such tests can be effectively administered on illiterates, children and deaf persons also. Some of the performance tests claim to be suitably used at persons from different cultures and prefer to be called as culture-free, culture-fair, culture-reduced and cross-cultural tests.

3.4.1 Types of Intelligence Scales

There are many types of intelligence a few of which are presented below.

3.4.1.1 Stanford-Binet Test

Terman had revised the Stanford Binet with the help of Maud Merrill in 1937 as the *Revised Stanford-Binet Intelligence Scale*. The revision included two alternate forms, the L form and the M form, each with 129 items.

The third revision of the Stanford-Binet came after Terman's death in 1960 and was constructed primarily by Merrill. The *Stanford-Binet Intelligence Scale, Form L-M*, was different from its predecessor in that it included a deviation intelligence quotient with a normative mean of 100 and a standard deviation of 16. This

version also included the 142 most pertinent items from the two previous forms of the test (Roid, 2003).

The fourth revision of the Stanford-Binet, the Stanford-Binet Intelligence Scales (SB4) came in 1986 and retained much of the content of the Form L-M edition. The same age range was covered; many of the same items and tasks were retained, and the basal and ceiling procedures were quite similar.

The greatest advance of the fourth edition was that, like the fifth edition, the fourth edition was based on a hierarchical model of intelligence. The four main areas assessed were verbal reasoning, abstract/visual reasoning, quantitative reasoning, and short-term memory. The fourth edition not only provided an overall intelligence quotient, but composite scores as well. Furthermore, to establish a basal level, the Vocabulary subtest of the fourth edition was used as a routing subtest, along with the subject's chronological age (Roid, 2003).

The latest version of the test, the Stanford- Binet Intelligence Scales–Fifth Edition (SB5) differs significantly from the SB4 with regard to theoretical structure, as the SB5 adheres rather strictly to the Cattell-Horn-Carroll (CHC) cognitive theory and the SB4 adheres to a less strict psychometric design.

The changes between the fourth and the fifth editions of the Binet scale included changes in the layout of the test, norm standards, and the underlying theoretical structure of the instrument. (Roid, 2003).

The SB5 is used to assess intellectual ability in individuals between the ages of two and 89 years, is individually administered, and contains 10 subscales. The three areas assessed by the SB5 are: general cognitive functioning, verbal and nonverbal intelligence and five CHC factors formed into groups along verbal/ nonverbal measures. The nonverbal portion of the SB5 accounts for 50% of the test and ranges across all factors, which is unique to the SB5 among cognitive batteries.

The five CHC factors that the SB5 measures are Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory. Together, the ten subtests yield an overall estimate of cognitive functioning, which is the Full Scale Intelligence Quotient (Roid, 2003) and nonverbal contrast, an abbreviated version, and a nonverbal form of the test.

Composites and subtests of the SB5

The SB5 is comprised of 5 composite scores each with a verbal and a nonverbal test-let, for a total of 10 subtests. Structure of the test is given below:

Factor Indices	**Domains**	
	Nonverbal	**Verbal**
Fluid Reasoning	*Activity: Object-Series/ Matrices* Requires the ability to solve novel figural problems and identify sequences of pictured objects or matrix-type figural and geometric patterns.	*Activities: Early Reasoning, Verbal Absurdities, Verbal Analogies* Requires the ability to analyse and explain, using deductive and inductive reasoning, problems involving cause effect connections in pictures, classification of objects, absurd statements, and interrelationships among words.

Knowledge	*Activity: Procedural Knowledge, Picture Absurdities* Requires knowledge about common signals, actions, and objects and the ability to identify absurd or missing details in pictorial material.	*Activity: Vocabulary* Requires the ability to apply accumulated knowledge of concepts and language and to identify and define increasingly difficult words.
Quantitative Reasoning	*Activity: Nonverbal Quantitative Reasoning* Requires the ability to solve increasingly difficult pre-mathematic, arithmetic, algebraic, or functional concepts and relationships depicted in illustrations.	*Activity: Verbal Quantitative Reasoning* Requires the ability to solve increasingly difficult mathematical tasks involving basic numerical concepts, counting, and word problems.
Visual-Spatial Processing	*Activity: Form Board, Form Patterns* Requires the ability to visualise and solve spatial and figural problems presented as "puzzles" or complete patterns by moving plastic pieces into place.	*Activity: Position and Direction* Requires the ability to identify common objects and pictures using common visual-spatial terms such as "behind" and "farthest left," explain spatial directions for reaching a pictured destination, or indicate direction and position in relation to a reference point
Working Memory	*Activity: Delayed Response, Block Span* Requires the ability to sort visual information in short-term memory and to demonstrate short-term and working memory skills for tapping sequences of blocks.	*Activity: Memory for Sentences, Last Word* Requires the ability to demonstrate short-term and working memory for words and sentences and to store, sort, and recall verbal information in short-term memory.

Scoring and Interpretation

The SB5 can be hand-scored or scored with optional scoring software. At the most granular level of the norm-referenced scores are the ten subtest scores (scaled scores have a mean of 10, SD=3, score range 1-19).

These subtest scores combine to form four types of composite scores: factor index, domain, abbreviated, and full scale (each with scaled score means of 100, SD=15, score range 40-160). Two subtests (one verbal, the other its nonverbal complement) combine to form each factor index.

There are two domain scales: Nonverbal IQ (combines the five nonverbal subtests) and Verbal IQ (combines the five verbal subtests). Two routing subtests combine to form the Abbreviated Battery IQ. Finally, the Full Scale IQ combines all ten subtests.

The Change-Sensitive Scores (CSSs) use item response theory scaling to convert the raw score totals on the composite scales described above into criterion-referenced levels of ability. These scales, as with the norm-referenced scores,

have excellent measurement properties. Because the CSSs reference absolute levels of ability, they provide a means to compare changes in an individual's scores over time. Scores range from the 2-year-old level (about 430) to the adult level (about 520). All of the SB5 items have been calibrated to this scale, and the difficulty of each item has a location along that scale. The scores will be particularly useful for the evaluation of extreme performance levels.

The SB5 also offers age-equivalent scores derived from CSSs, along with a CSS-based abbreviated battery score making use of raw scores from the Nonverbal Reasoning and Verbal Knowledge subtests. Finally, the Interpretive Manual describes a hand-scoring procedure for deriving an extended Full Scale IQ score that allows for scores below 40 and above 160. A variety of interpretive frameworks, such as Examiner's Manual, Interpretive Manual, or the SB5 Scoring Pro software, can be applied to the results of this test.

3.4.1.2 Wechsler Intelligence Scales

The first Wechsler intelligence scale came in 1939. After that Wechsler scales have gone through several successive revisions for three different categories: (i) for adults (16-90 years), (ii) for school-going children (6-16 years) and (iii) for pre-schoolers (2½-7 years). Year-wise development of these scales is given below:

Wechsler Adult Intelligence Scale (WAIS)	Wechsler Intelligence Scale for Children (WISC)	Wechsler Preschool and Primary Scale of Intelligence
Wechsler-Bellevue-I:1939	Wechsler-Bellevue-II: 1946	WPPSI: 1967
WAIS: 1955	WISC: 1949	WPPSI-R: 1989
WAIS-R: 1981	WISC-R: 1974	WPPSI-III: 2002
WAIS-III: 1997	WISC-III: 1991	
WAIS-IV: 2008	WISC-IV: 2003	

Since its publication, the Wechsler intelligence scales have been the most used instruments among clinical and school psychologists for assessing the cognitive abilities of children, adolescents and adults. Wechsler viewed the construct of intelligence not only as a global entity but also as an aggregate of specific abilities that are qualitatively different. Intelligence is global because it characterises the individual's behaviour as a whole.

3.4.2 Wechsler's Intelligence Scales

Wechsler (1944) defined intelligence in a general behavioural term as the capacity to act purposefully, to think rationally and to deal effectively with the environment. He also believed that intelligence is specific because it is made up of elements or abilities that are qualitatively different and can be measured by a variety of tests. Factor analytic researches of intelligence test scores also suggest that intelligence is composed of specific abilities that form clusters of higher order ability domains.

3.4.2.1 Structure of WAIS-IV

The current version of the test, the WAIS-IV, which was released in 2008, is composed of 10 core subtests and five supplemental subtests, with the 10 core subtests comprising the Full Scale IQ. With the new WAIS-IV, the verbal/ performance subscales from previous versions were removed and replaced by

the index scores. The General Ability Index (GAI) was included, which consists of the Similarities, Vocabulary and Information subtests from the Verbal Comprehension Index and the Block Design, Matrix Reasoning and Visual Puzzles subtests from the Perceptual Reasoning Index. The GAI is clinically useful because it can be used as a measure of cognitive abilities that are less vulnerable to impairment.

Indices and scales

There are four index scores representing major components of intelligence:

- Verbal Comprehension Index (VCI)
- Perceptual Reasoning Index (PRI)
- Working Memory Index (WMI)
- Processing Speed Index (PSI)

Two broad scores are also generated, which can be used to summarize general intellectual abilities:

- Full Scale IQ (FSIQ), based on the total combined performance of the VCI, PRI, WMI, and PSI
- General Ability Index (GAI), based only on the six subtests that comprise the VCI and PRI

3.4.2.2 Subtests

The Verbal Comprehension Index includes four tests:

- Similarities: Abstract verbal reasoning (e.g., "In what way are an apple and a pear alike?")
- Vocabulary: The degree to which one has learned, been able to comprehend and verbally express vocabulary (e.g., "What is a guitar?")
- Information: Degree of general information acquired from culture (e.g., "Who is the president of Russia?")
- Comprehension [Supplemental]: Ability to deal with abstract social conventions, rules and expressions (e.g., "What does *Kill 2 birds with 1 stone* metaphorically mean?")

The Perceptual Reasoning Index comprises five tests

- Block Design: Spatial perception, visual abstract processing and problem solving
- Matrix Reasoning: Nonverbal abstract problem solving, inductive reasoning, spatial reasoning
- Visual Puzzles: non-verbal reasoning
- Picture Completion [Supplemental]: Ability to quickly perceive visual details
- Figure Weights [Supplemental]: quantitative and analogical reasoning

The Working Memory Index is obtained from three tests

- Digit span: attention, concentration, mental control (e.g., Repeat the numbers 1-2-3 in reverse sequence)
- Arithmetic: Concentration while manipulating mental mathematical problems (e.g., "How many 45-cent stamps can you buy for a dollar?")

- Letter-Number Sequencing [Supplemental]: attention and working memory (e.g., Repeat the sequence Q-1-B-3-J-2, but place the numbers in numerical order and then the letters in alphabetical order)

3.4.2.3 The Processing Speed Index Includes Three Tests

- Symbol Search: Visual perception, speed
- Coding: Visual-motor coordination, motor and mental speed
- Cancellation [Supplemental]: visual-perceptual speed

Interpretation

Wechsler scales use an innovative deviation IQ score for interpretation of an individual's score. The deviation IQ is based on standard scores computed with the same distributional characteristics at all ages and makes comparison among peers more meaningful and the interpretation more straightforward. The WAIS-IV was standardized on a sample of 2,200 people in the United States ranging in age from 16 to 90. An extension of the standardisation has been conducted with 688 Canadians in the same age range. The median Full Scale IQ is centered at 100, with a standard deviation of 15. In a normal distribution, the IQ range of one standard deviation above and below the mean (i.e., between 85 and 115) is where approximately 68% of all adults would fall.

3.4.3 Kaufman Assessment Scales

The first Kaufman Scale, Kaufman Assessment Battery for Children (K-ABC; Kaufman & Kaufman, 1983) was developed in the late 1970s and early 1980s and was published in 1983, during a time when IQ was largely a Wechsler-Binet monopoly. This scale intended to bridge the gap between theories of intelligence and measures of intelligence. Two important tests of this series are given below:

3.4.3.1 Kaufman Assessment Battery for Children

The second revision of K-ABC, the KABC-II was published in 2004 for the Age range of 3 to 18 years. This test measures learning (long-term retrieval), sequential processing (short-term memory), simultaneous processing (visualisation), planning (fluid ability) and verbal knowledge (crystallised ability). The KABC-II is founded in two theoretical models: Luria's (1973) neuropsychological model, featuring three blocks, and the Cattell-Horn-Carroll (CHC) approach to categorising specific cognitive abilities (Carroll, 1997). The KABC-II yields a separate global score for each of these two theoretical models: The global score measuring general mental processing ability from the Luria perspective is the Mental Processing Index (MPI), and global score measuring general cognitive ability from the CHC perspective is the Fluid-Crystallised Index (FCI). The key difference between these two global scores is that the MPI (Luria's theory) *excludes* measures of acquired knowledge, whereas the FCI (CHC theory) *includes* measures of acquired knowledge. Only one of these two global scores is computed for any examinee. Prior to testing a client, examiners choose the interpretive system (i.e., Luria or CHC) that best fits with both their personal orientation and the reason for referral. Deciding which interpretive system to use will dictate which global score is reported and also whether measures of acquired knowledge are included from the core battery. The authors of the KABC-II clearly state in the manual that "the CHC model should generally be the model of choice, except in cases where the examiner believes that including measures

of acquired knowledge/crystallised ability would compromise the validity of the Fluid-Crystallised Index." In those cases, the Luria global score (MPI) is preferred.

3.4.3.2 Structure of the KABC-II

The complete scale description of KABC-II is given in the table below:

Scales	Subtests Description
Sequential/*Gsm*	
Word Order	The child touches a series of silhouettes of common objects in the same order as the examiner said the names of the objects; more difficult items include an interference task (colour naming) between the stimulus and response
Number Recall	The child repeats a series of numbers in the same sequence as the examiner said them, with series ranging in length from two to nine numbers; the numbers are single digits, except that 10 is used instead of 7 to ensure that all numbers are one syllable.
Hand Movements	The child copies the examiner's precise sequence of taps on the table with the fist, palm, or side of the hand.
Simultaneous/*Gv*	
Rover	The child moves a toy dog to a bone on a checkerboard like grid that contains obstacles (rocks and weeds) and tries to find the "quickest" path—the one that takes the fewest moves.
Triangles	For most items, the child assembles several identical rubber triangles (blue on one side, yellow on the other) to match a picture of an abstract design; for easier items, the child assembles a different set of colourful plastic shapes to match a model constructed by the examiner.
Conceptual Thinking	The child views a set of four or five pictures and identifies the one picture that does not belong with the others; some items present meaningful stimuli and others use abstract stimuli.
Face Recognition	The child attends closely to photographs of one or two faces that are exposed briefly and then selects the correct face or faces, shown in a different pose, from a group photograph.
Gestalt Closure	The child mentally fills in the gaps in a partially completed inkblot drawing and names (or describes) the object or action depicted in the drawing.
Block Counting	The child counts the exact number of blocks in various pictures of stacks of blocks; the stacks are configured such that one or more blocks is hidden or partially hidden from view.

Planning/*Gf*	
Pattern Reasoning	The child is shown a series of stimuli that form a logical, linear pattern, but one stimulus is missing; the child completes the pattern by selecting the correct stimulus from an array of four to six options at the bottom of the page (most stimuli are abstract, geometric shapes, but some easy items use meaningful stimuli).
Story Completion	The child is shown a row of pictures that tell a story, but some of the pictures are missing. The child is given a set of pictures, selects only the ones that are needed to complete the story, and places the missing pictures in their correct location.
Learning/*Glr*	
Atlantis	The examiner teaches the child the nonsense names for fanciful pictures of fish, plants, and shells; the child demonstrates learning by pointing to each picture (out of an array of pictures) when it is named.
Atlantis Delayed	The child demonstrates delayed recall of paired associations learned about 15–25 minutes earlier during Atlantis by pointing to the picture of the fish, plant, or shell that is named by the examiner.
Rebus Learning	The examiner teaches the child the word or concept associated with each particular rebus (drawing), and the child then "reads" aloud phrases and sentences composed of these rebuses.
Rebus Learning Delayed	The child demonstrates delayed recall of paired associations learned about 15–25 minutes earlier during Rebus by "reading" phrases and sentences composed of those same rebuses.
Knowledge/*Gc*	
Riddles	The examiner provides several characteristics of a concrete or abstract verbal concept, and the child has to point to it (early items) or name it (later items).
Expressive Vocabulary	The child provides the name of a pictured object.
Verbal Knowledge	The child selects from an array of six pictures the one that corresponds to a vocabulary word or answers a general information question.

(*Source: KABC-II Manual*; Kaufman & Kaufman, 2004).

3.5 STANDARD SCORES AND SCALED SCORES

The KABC-II's two global scores, the MPI and FCI, both are standard scores with a mean of 100 and a standard deviation (SD) of 15. However, only *one* of these two global scores is computed and interpreted for any child or adolescent who is evaluated, based on the examiner's choice of the Luria or CHC model for that individual. Like the MPI and FCI, the KABC-II Nonverbal Index is also a

standard score with a mean of 100 and SD of 15. The five additional KABC-II scales offered for ages 4–18 each have a mean of 100 and SD of 15 (but only the MPI and FCI are offered at age 3). All KABC-II subtests have a mean of 10 and SD of 3. The Core subtest standard scores contribute to the scales, but the Supplementary scaled scores do not (except for the special Nonverbal scale).

3.5.1 The Kaufman Adolescent and Adult Intelligence Test

The Kaufman Adolescent and Adult Intelligence Test (KAIT) was developed by Alan S. Kaufman and Nadeen L. Kaufman in 1993 and is an individually administered intelligence test for individuals ranging from 11 to 85-plus years of age. It has a strong theoretical base integrating Horn and Cattell's concept of fluid and crystallised intelligence, Luria and Golden's notion of frontal lobe planning ability, and Piaget's construct of formal operational thought. The test is comprised of crystallised scale (measuring concepts acquired from schooling and acculturation) and fluid scale measuring (ability to solve new problems). Core battery of test is composed of three subtests from each of the scales. The expanded battery is used with persons having neurological damage. For the persons with cognitive impairment, who cannot take the full battery, mental status test is administered to assess the person's attention and orientation.

Self Assessment Questions

1) Describe the development of Stanford-Binet Scales. Explain the structure and interpretation of SB5.

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2) What are the variants of Wechsler Scales? Describe the structure and interpretation of WAIS-IV.

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3) What are the theoretical bases of Kaufman Assessment Scales? Describe KABC-II and KAIT.

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3.6 LET US SUM UP

Intelligence tests measure individual differences in terms of cognitive functions and intellectual abilities. Some of the intelligence tests theoretically incline to measure a general intellectual ability and give an integrated intelligence score (IQ), while, other tests are focussed on measuring groups of factors for a variety of mental activities. Tests also differ in the ways of administration (individual and group tests) and form and nature of their items (verbal/paper-pencil tests and non-verbal/performance tests). Culture-free tests claim to be usable to the persons from different cultures. Modern intelligence testing started with Simon-Binet test in 1905. A series of revisions of the test has been published by Terman and the currently used version of the test is SB5. A number of variants of Wechsler scales have been most used instruments of cognitive assessment and very useful tool for clinical and neuro-psychological practitioners and researchers. The test introduced an innovative deviation IQ based on the standard scores. The currently used Kaufman assessment scales, KABC-II, is the most theoretically grounded and psychometrically rigorous test. The test is based on two theoretical models: Luria's neuropsychological model and the Cattell-Horn-Carroll (CHC) approach to categorising specific cognitive abilities. The provides separate global scores for each of these two theoretical models: The global score measuring general mental processing ability from the Luria perspective is the Mental Processing Index, and global score measuring general cognitive ability from the CHC perspective is the Fluid-Crystallised Index.

3.7 UNIT END QUESTIONS

1) Define intelligence tests and explain the theoretical background of measurement of intelligence.
2) Describe the history of intelligence tests and present an account of the concepts of IQ and deviation IQ.
3) Explain the types of intelligence tests with their relative advantages and disadvantages.
4) Describe the development of Simon-Binet tests. Also present a detailed account of SB5.
5) Provide a historical account of development of variants of Wechsler Scales. Describe the nature, structure and interpretation of WAIS-IV.
6) By explaining theoretical grounds of Kaufman's Scales present a complete description of structure and interpretation of KABC-II and KAIT.

3.8 GLOSSARY

Intelligence tests : Tests defined as a test to evaluate general level of cognitive functions and intellectual ability.

General factor : Factor which is essentially common in all the intellectual activities.

Specific factors : Factors required for specific intellectual activities.

IQ : Intelligence quotient is an integrated intelligence score obtained by dividing person's mental age by

his/her chronological or real age and further multiplied by hundred ({MA/CA} X 100).

Individual test : Test that can be administered at only one person at a time.

Group tests : Tests that can be administered on a group of individuals at one go.

Verbal/Paper-pencil tests : Tests that use written language for its items.

Non-verbal/ Performance tests : Items of performance tests do not use language, are manipulative in nature and examinees are required to manipulate the items in a particular and desired manner.

Culture-free tests : Performance tests that claim to be suitably used at persons from different cultures.

Deviation IQ : The deviation IQ is based on standard scores computed with the same distributional characteristics at all ages and makes intra-group comparison meaningful.

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UNIT 4 CREATIVITY AND PROBLEM SOLVING

Structure

4.0 INTRODUCTION

Human being is exceptionally blessed with the higher level thinking abilities of creativity and problem solving. Such activities require use of already stored information along with the information concurrently received from the environment. A thorough account of these multi-step processes will be presented in this unit. First of all, we will discuss meaning, aspects and stages of creativity. This will be followed by a description of measurement of creativity and its relationship with intelligence. We will also discuss meaning, stages and strategies of problem solving. Finally, factors affecting problem solving will be discussed.

4.1 OBJECTIVES

After reading this unit, you will be able to:

- Explain meaning, aspects and stages of creativity;
- Describe the tests to measure creativity and relate it with intelligence;
- Explain meaning, stages and strategies of problem solving; and
- Analyse the factors affecting problem solving.

4.2 CREATIVITY

The most advanced thought process, creativity, involves production of uncommon and novel ideas that are highly relevant to the situation. Creativity is defined as something different from intelligence and as a parallel construct to intelligence, but it differs from intelligence in that it is not restricted to cognitive or intellectual functioning or behaviour. Instead, it is concerned with a complex mix of motivational conditions, personality factors, environmental conditions, chance factors, and even products (Michalko, 1998).

4.2.1 Meaning and Aspects of Creativity

Creativity is a goal directed thinking which is unusual, novel and useful. Many of such creative thinking become so important that they influence the whole human civilisation and are called as historical creativity. The Mona Lisa, the laws of thermodynamics, the laws of motion, the theory of relativity are some of the ideas that were never thought before and changed the human civilisation altogether in a great way in their respective spheres of life. Although we can accept its existence and importance, it has been a highly difficult task for the researchers to define creativity.

Newell, Shaw and Simon (1963) have explained the nature of creativity on the basis of following four criteria:

a) Novelty and usefulness

b) Rejects previously accepted ideas

c) Requires intense motivation and persistence

d) Results from organising the unclear situation in a coherent, clear and new way.

Sternberg (2006) reports five commonalities in the research of creativity. These are:

1) Creativity involves thinking that aims at producing ideas or products that are relatively novel and that are, in some respect, compelling.

2) Creativity has some domain-specific and domain-general elements in the sense that it needs some specific knowledge, but there are certain elements of creativity that cut across different domains.

3) Creativity is measureable, at least to some extent.

4) Creativity can be developed and promoted.

5) Creativity is not highly rewarded in practice, as it is supposed to be in theory.

Sternberg and Lubart (1999) define creativity as the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful concerning tasks constrains).

Runco (2007) categorised these definitions of creativity as involving the creation of something new and useful and calls them as "products definitions" of creativity. However, he thought that creative thinking did not essentially require tangible creative products; rather the process should be more focused in defining creativity.

Studies in cognitive psychology have tried to understand the process of creative thinking. These researches assumed that creativity is just extraordinary results of ordinary processes (Smith, Ward & Finke 1995). The process of creativity is thought to have following four characteristics:

1) It is imaginative involving imagination, since it is the process of generating something original.

2) It is purposeful, that is, creativity is imagination put into action towards an end.

3) It produces something original in relation to one's own previous work, to their peer group or to anyone's previous output in a particular field.

4) It has value in respect to the objective it was applied for. Creativity involves not only the generation of ideas, but also evaluation of them, and deciding which one is the most adequate one.

Beghetto and Kaufman (2007) conceptualised creativity in three different ways. They defined creativity as novel and personally meaningful interpretation of experiences, actions, and events. However, the novelty and meaningfulness of these interpretations need not require to be original or (even meaningful) to others. Indeed, the judgment of novelty and meaningfulness that constitutes creativity is an intrapersonal judgment. This intrapersonal judgment is what distinguishes creativity from other forms of creative expressions.

There are two types of creativeity (i) little-c (or everyday) creativity and (ii) Big-C (or eminent) creativity. The latter two forms of creativity rely on interpersonal and historical judgments of novelty, appropriateness, and lasting impact.

4.2.2 Investment and Confluence Theory of Creativity

Sternberg (2006) has proposed investment and confluence theory to understand creativity. According to the investment theory, creativity requires a confluence of six distinct but interrelated resources: intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment. Although levels of these resources are sources of individual differences, often the decision to use a resource is a more important source of individual differences.

Intellectual skills: Three intellectual skills are particularly important: (a) the synthetic skill to see problems in new ways and to escape the bounds of conventional thinking, (b) the analytic skill to recognise which of one's ideas are worth pursuing and which are not, and (c) the practical–contextual skill to know how to persuade others of—to sell other people on—the value of one's ideas. The confluence of these three skills is also important. Analytic skills used in the absence of the other two skills results in powerful critical, but not creative, thinking. Synthetic skill used in the absence of the other two skills results in new ideas that are not subjected to the scrutiny required to improve them and make them work. Practical–contextual skill in the absence of the other two skills may result in societal acceptance of ideas not because the ideas are good, but rather, because the ideas have been well and powerfully presented.

Knowledge: On the one hand, one needs to know enough about a field to move it forward. One cannot move beyond where a field is if one does not know where it is. On the other hand, knowledge about a field can result in a closed and

entrenched perspective, resulting in a person's not moving beyond the way in which he or she has seen problems in the past. Knowledge thus can help, or it can hinder creativity.

Thinking styles: Thinking styles are preferred ways of using one's skills. In essence, they are decisions about how to deploy the skills available to a person. With regard to thinking styles, a legislative style is particularly important for creativity, that is, a preference for thinking and a decision to think in new ways. This preference needs to be distinguished from the ability to think creatively: Someone may like to think along new lines, but not think well, or vice versa. It also helps to become a major creative thinker, if one is able to think globally as well as locally, distinguishing the forest from the trees and thereby recognising which questions are important and which ones are not.

Personality: Numerous research investigations have supported the importance of certain personality attributes for creative functioning. These attributes include, but are not limited to, willingness to overcome obstacles, willingness to take sensible risks, willingness to tolerate ambiguity, and self-efficacy. In particular, buying low and selling high typically means defying the crowd, so that one has to be willing to stand up to conventions if one wants to think and act in creative ways. Often creative people seek opposition; that is, they decide to think in ways that countervail how others think. Note that none of the attributes of creative thinking is fixed. One can decide to overcome obstacles, take sensible risks, and so forth.

Motivation: Intrinsic, task-focused motivation is also essential to creativity. The research of Amabile (1983) and others has shown the importance of such motivation for creative work and has suggested that people rarely do truly creative work in an area unless they really love what they are doing and focus on the work rather than the potential rewards. Motivation is not something inherent in a person: One decides to be motivated by one thing or another. Often, people who need to work in a certain area that does not particularly interest them will decide that, given the need to work in that area, they had better find a way to make it interest them. They will then look for some angle on the work they need to do that makes this work appeal to rather than bore them.

Environment: Finally, one needs an environment that is supportive and rewarding of creative ideas. One could have all of the internal resources needed to think creatively, but without some environmental support (such as a forum for proposing those ideas), the creativity that a person has within him or her might never be displayed.

Confluence: Concerning the confluence of these six components, creativity is hypothesized to involve more than a simple sum of a person's level on each component. First, there may be thresholds for some components (e.g., knowledge) below which creativity is not possible regardless of the levels on other components. Second, partial compensation may occur in which strength on one component (e.g., motivation) counteracts a weakness on another component (e.g., environment). Third, interactions may occur between components, such as intelligence and motivation, in which high levels on both components could multiplicatively enhance creativity.

4.2.3 Aspects of Creativity

Guilford (1986) considered creative thinking as involving divergent thinking, which emphasises fluency, flexibility, originality, and elaboration. Guilford, however, noted that creative thinking is not the same as divergent thinking, because creativity requires sensitivity to problems as well as redefinition abilities, which include transformations of thought, reinterpretations, and freedom from functional fixedness in driving unique solutions. In order to develop Torrance Tests of Creative Thinking (TTCT) and in its further revisions, Torrance (1966, 1974) has explained six components of creativity. He has described these aspects of creativity in terms of their mode of measurement. These aspects of creativity are:

1) *Fluency:* The number of relevant ideas; shows an ability to produce a number of figural images.
2) *Flexibility:* Flexibility is the individual's ability to produce not only a large number of responses, ideas or solutions to a problem, but also a variety of responses, ideas or solutions to a problem.
3) *Originality:* The number of statistically infrequent ideas; shows an ability to produce uncommon or unique responses.
4) *Elaboration:* The number of added ideas; demonstrates the subject's ability to develop and elaborate on ideas.
5) *Abstractness of Titles:* The degree beyond labeling; based on the idea that creativity requires an abstraction of thought. It measures the degree a title moves beyond concrete labeling of the pictures drawn.
6) *Resistance to Premature Closure:* The degree of psychological openness; based on the belief that creative behaviour requires a person to consider a variety of information when processing information and to keep an "open mind."

Self Assessment Questions

1) Define the process of creativity.

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2) Describe that how different psychologists differ in understanding creativity.

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3) Explain that how Investment and Confluence Theory of approaches creativity.

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4) Give an account of aspects of creative thinking.

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4.2.4 Stages of Creativity

The history of research on stages of creativity began with Graham Wallas (1926) who suggested that creative thinking follows four successive steps:

Stage of preparation: The subject begins to gather information about the problem to be solved and attempts some solutions. This stage is characterised by a state of trial-and-error in learning. Therefore, the subject is advised to learn as much as possible about the problem area. In preparation the thinker begins recalling personal experiences and investigating in all different directions to gather information about the problem to be solved. The object of defining the focus question of interest is to list all concepts associated with the focus question. Since the goal from this procedure is to generate the largest possible list, the thinker should not worry about redundancy, relative importance, or relationships at this point.

Stage of incubation: In the second stage the solution exists but is not clear. The subject must not intentionally work on the problem. Instead it is allowed to sink into the unconscious. In this stage the solution exists but is not clear. Therefore, the thinker must not intentionally work on the problem. Instead, he/she should be allowed to sink into the unconscious and the thinker is advised to relax and reflect on his/her focus question which might lead him/her to modification of the focus question.

Stage of illumination: In the third stage the subject suddenly experiences insight into the problem when a new solution, idea, or relationship emerges. In other words, the subject attempts to reformulate his/her ideas or to formulate new ones. The subject is more active and more conscious work is needed in this stage. In the stage of illumination the thinker experiences insight into the problem when a new solution, idea, or relationship emerges. Thus, he/she attempts to reformulate his/her ideas or to formulate new ones.

Stage of verification: Finally, the subject tries and checks the solution. In this stage some modification may also occur to ideas reached in the previous stages. In the stage of verification the thinker tests, tries and checks the solution he/she created. Since this stage is the final one, the thinker may well make some modification to his/her ideas which he/she reached in the previous stages. In this stage thinker should rework the structure of his/her map to represent his/her collective understanding of the interrelationships and connections among groupings, which may include adding, subtracting, or changing super-ordinate concepts, thus, he/she may need to review his/her concept map as he/she gains new knowledge or new insights.

In some situations, the above stages may appear in a different order, or combined into two or three stages. They also do not occur regularly. For example, sometimes the subject's knowledge of the problem area allows him/her to pass over the first stage (preparation) and move on to the next stage (incubation) or even to the third stage.

4.2.5 Creativity and Intelligence

In one extreme opinion, creativity and intelligence are regarded as totally independent of each other. Intelligence is not supposed to influence creativity. Creativity is viewed as a mental operation accessible to everyone. It is supposedly dependent on domain-specific knowledge (i.e. the amount of exposure to and expertise in a given field) and deliberate practice.

This position denies not only the influence of intelligence, but of any individual difference beyond knowledge and motivational factors, on creativity.

A high IQ has proven as insufficient for creativity ever since Terman's (1925) famous longitudinal study of 1528 highly gifted children, which had a mean IQ of 151. While most of these children achieved remarkable occupational success in later life, none of them showed a noteworthy sign of creativity. Most of the studies concerning the association between psychometric intelligence and creativity yielded only a weak relationship. For example, Torrance (1977) reported that the median of 178 correlation coefficients between IQ and the TTCT was only .20. Also, factor analyses of IQ and creativity tests yielded separate factors.

However, a creative person's IQ has been demonstrated to be at least a standard deviation above the mean, often more. Guilford (1967) suggested a hypothesis that a minimal level of IQ, often arbitrary set to 120, should be necessary, but not sufficient for creativity. Creative achievement was thought to be impossible below this threshold. Guilford also proposed that scatter plots of IQ and creativity should show a triangular pattern (which gave Guilford's claim sometimes the name 'triangularity hypothesis') with no data points in the low IQ/high creativity quadrant. This threshold view of creativity is so plausible that it is widely accepted, though empirical test are scarce and more likely to show a disconfirming tendency.

Hayes (1989) proposed an alternative 'certification hypothesis', which doubted intrinsic links between creativity and intelligence. Instead, it stated that most possibilities to display a recognisable level of creativity, like occupations in architecture or science, simply require a high level of formal education. Since academic performance is correlated with IQ, society simply denies creative individuals of low IQ the chance to express their talent adequately.

4.2.6 Measurement of Creativity

Houtz and Krug (1995) provide a review of several tests developed for the assessment of creativity. The review reveals that most of the tests of creativity intend to measure divergent thinking. Within the category of divergent thinking, Houtz and Krug (1995) present the Torrance Test of Creative Thinking (TTCT) (Torrance 1966), The Wallach and Kogan Tests, The Guilford Battery.

The most widely used test on creativity is the *Torrance Test of Creative Thinking* (TTCT). It is also the one that has the most extended research on their reliability and validity (Kim 2006). This test has been translated into more than 30 languages and it is used in different places as a tool to assess creative potential. It is based on Guilford's Structure of the Intellect (SOI) battery that included some measures of divergent thinking. Thus, it measures creativity through divergent thinking.

The TTCT was developed in 1966, and it has been re-normed four times: 1974, 1984, 1990 and 1998. There are two forms, TTCT-Verbal and Figural with two parallel tests (form A and B). Each test is expected to measure

1) Fluency: The number of ideas: Total number of relevant responses.
2) Originality: The rarity of ideas: Number of statistically infrequent ideas. The score is 0 if the idea is common, and 1 if it is unique.
3) Elaboration: The number of added ideas.
4) Flexibility: Number of categories of the relevant responses.

In 1990 Torrance deleted the flexibility scale, since it correlated highly with fluency and added two measures of creative potential, viz., (i) abstractness of titles and (ii) resistance to premature closure.

While (i) abstractness of title refers to the degree a title moves beyond concrete labelling of pictures drawn, (ii) resistance to premature closure pertains to measure the degree of psychological openness. The test can be administered in around 30 minutes, but the process of scoring requires some training and specific country norms.

The 1998 manual provides norms for the United States and includes both grade related and age related norms. Thus, there is some country specificity in the measurement of creativity. Kim (2006) reported some normative measures in other countries. These norms have usually been developed for research activities.

Criticisms against TTCT

There are 4 main criticisms against this test and these are:

1) The response set might influence the results. Thus, different order in the presentation of the items leads to different results.
2) Creativity tests administered under different conditions lead to differences in performance.
3) Raters of the TTCT might differ considerably in their scores to a similar person.
4) The structure of the test itself is inadequate.

Self Assessment Questions

1) Explain the stages of creativity.

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2) Describe how creativity is related to intelligence.

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3) Explain the threshold hypothesis.

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4) Give an account of measurement of creativity.

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4.3 PROBLEM SOLVING

The thought process involved in a person's effort to remove obstacles in the way to achieve the goal state is called problem solving. Such a process is involved in critical thinking in taking many important decisions of life as well as in solving simple routine problems. Psychological researches have uncovered many aspects of problem solving behaviour which will be discussed in the following sections.

4.3.1 Terms Related to Problem Solving

Original or initial state: Problem solving begins with a certain original state called the initial state of a problem.

Goal or end state: This is what will be reached if the problem is solved. The goal state is what is desired by the person. The goal state has some properties defined by the person.

The person concerned who is with the initial state of the problem and wants to reach the goal, puts in efforts to reach that goal. There may be obstacles to reach the goal which will have to be overcome.

Person / operator: This refers to the person who is in the initial state and strives to achieve the coal or end state through application of certain skills and techniques which would facilitate overcoming the obstacle and reaching the goal state. Operator manipulates the elements involved in the problem internally with the help of some global or personal symbols or visual images.

Problem space: Initial state, goal state and operator combine to form the problem space. The problem space includes a number of elements in it that are required to be organised in a particular manner. A successful understanding of the problem space would require: coherence, correspondence and relationship to background knowledge. Coherent understanding of the problem space refers to connecting the elements in a meaningful manner. A successful understanding also requires a close correspondence between the internal representation and the elements of the problem space. None of the elements should be left unmatched and also none of them should be mismatched. Therefore, proper matched connections should be made among all the elements.

Rules: These refer to rules that exist in converting the problem state into a goal state.

More specifically it may be stated that Problem solving behaviour begins with an obstacle or difference between *original* or *initial state* and *goal* or *end state*. The goal is desired by the person/s or *operator/s* in the situation and has some properties defined by the operator.., defined by some *rules*, to convert the problem state into the goal state.

An Example of Problem Solving: A classical example of problem solving behaviour may be explained with the help of Kohler's experiments with a chimpanzee. In one experiment, Kohler (1927) put a hungry chimpanzee (operator) in a closed cage with bananas hanging from the roof (goal state) and three boxes on the floor. It should be noted that the chimpanzee can come closer to the bananas only by putting all the three boxes together in vertical manner (rule). In Kohler's experiment, after a series of irrelevant behaviours the chimpanzee suddenly solved the problem and reached to the bananas. Such sudden solutions of the problem resulted from internal representation and understanding of the problem which was continuously going on in the chimpanzee's unconscious and is termed as insight by Kohler and other *Gestalt* psychologists.

4.3.2 Typologies of Problems

Well-defined and Ill-defined Problems

A problem is well-defined if there is a definable initial state and a goal state, definite number of operators well identified and clear and explicit rules and sub-goals to convert the initial state into the goal state.

The problem faced by the chimpanzee in the Kohler's experiment is a good example of a welldefined problem.

However an ill-defined problem is in which one or all of the elements of the problem space (initial state, goal state, operators and rules) are not clearly defined. Creation of a painting is a unique example of ill-defined problems.

Problems of Inducing Structure:

Problems of inducing structure require determining relationship among several elements of the problem. For example take the analogy problem in which the operator is required to find a structure in some elements with clearly defined rules. Example of structured elements are "bird to sky as fish is to water".

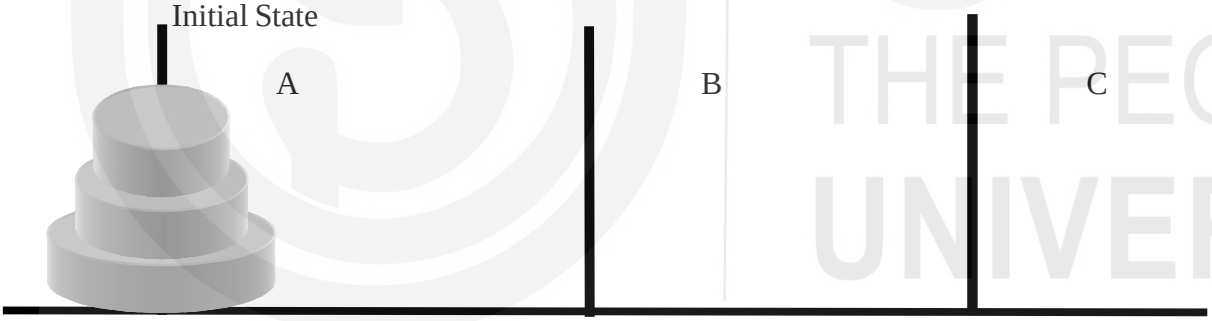
Solving analogy problems requires three types of cognitive skills:

1) Process of attribute discovery
2) Process of encoding
3) Process of comparing encoded attributes and evaluating attribute based structure among the elements.

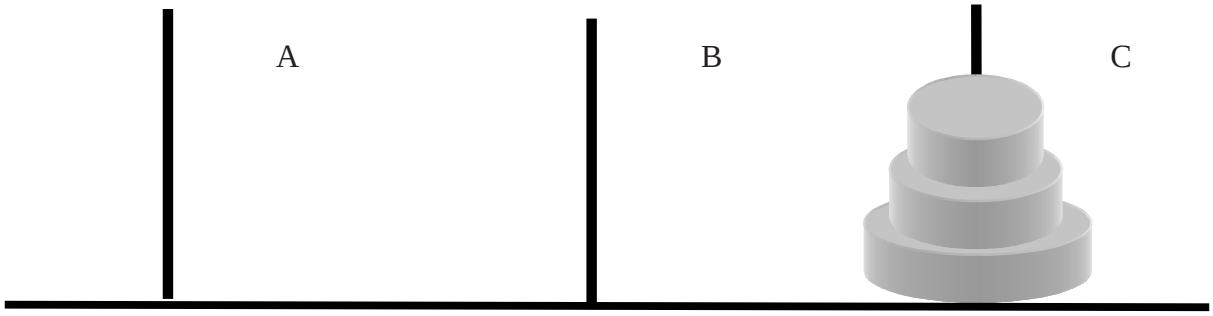
Problems of Transformation

Problems of transformation require finding a sequence of operations to transform the initial state into the goal state. A classic example of such a problem is Tower of Hanoi. A modified version of the problem is illustrated in the figure given below:

Initial State



Goal State



At the initial state, there are three discs placed in peg A. Operator is required to move all the three discs on to the peg C. Rules of the game are that only one and the top disc can be moved at a time and the bigger disc cannot be placed over the smaller one.

Problems of Arrangement:

Problems of arrangement requires the operator to rearrange the elements of the problem according to some criterion. In some of such problems the arrangement criterion is predefined, while in others the operator himself is required to discover it. An example of such problems is anagram in which order of letters of a word changed and the operator is asked to rearrange their sequence to form a meaningful word.

The cognitive skill needed to solve an anagram is constructive search by which operator systematically examines reasonable combinations of letters until the meaningful sequence is found.

4.3.3 Stages of Problem Solving

Gestalt psychologists suggest that problem solving behaviour also follows the stages that are followed in creative thinking: preparation, incubation, illumination or insight and verification. These stages have already been discussed in the earlier section.

According to Polya , there are four stages involved in problem solving and these are as given below

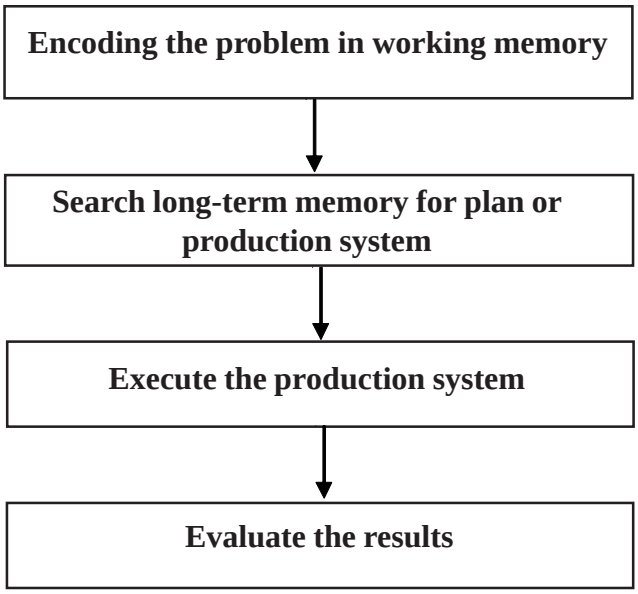
Stage 1: Define, understand and think about the problem. In this stage, there is identification of the actual problem, attributes of the problem, area of knowledge involved in solving the problem and collecting relevant information.

Stage 2: Devise a plan for solution. This stage includes thinking of alternate ways to solve the problem and preparing a flowchart of solution.

Stage 3: Carry out the plan. This stage of problem solving is to execute the solution of the problem.

Stage 4: Looking back. This involves verifying that the problem solved was the one originally defined, and also checking reasonableness, criteria and constraints as well as communicate results.

An information processing translation of the Polya's stages has also been described which is presented in the following model: (See figure below)



4.3.4 Strategies of Problem Solving

Even if the operator has all the basic knowledge and background skills, yet there is no guarantee that they will solve the problem successfully.

In order to be successful in solving a problem, an additional element needed is to have a general strategy that can be used for problem solving.

A strategy is a set of sequential steps (or procedure) used by a problem solver in arriving at a solution. The strategy should help the operator by guiding him/her to efficiently extract relevant data from the problem space and by giving a planned approach to solving the problem. Cognitive psychologists have described two major types of strategies generally used by an operator and these are termed as algorithms and heuristics. Let us see what these are:

4.3.4.1 Algorithms

An algorithm is a strategy that ensures the correct solution of the problem, if the well-defined rule of the solution is properly followed. In an anagram problem, an algorithm would be attempting all the possible letter sequences until the correct and meaningful word is found. There are four essential properties of an algorithm:

1) Each step of an algorithm must be exact. An algorithm must be precisely and unambiguously described, so that there remains no uncertainty.
2) An algorithm must terminate. The ultimate purpose of an algorithm is to solve a problem. If the process does not stop when executed, one will not be able to get any result from it. Therefore, an algorithm must contain a finite number of steps in its execution.
3) An algorithm must be effective. It must provide the correct answer to the problem.
4) An algorithm must be general. This means that it must solve every instance of the problem. For example, a program that computes the area of a rectangle should work on all possible dimensions of the rectangle, within the limits of the programming language and the machine.

Although algorithm is a guarantee to reach to the solution, the effort and time involved in using it is so great that a human operator rarely uses this strategy.

4.3.4.2 Heuristics

Heuristics are general suggestions or “rules of thumb” that are useful in solving a variety of problems. Heuristics are powerful and general. They do not ensure a correct solution to the problem. That is why there are so many of them and if one does not work, another may be tried upon. General heuristics are usually context free and apply across many different situations. Specific heuristics are used in specialised areas, like applying the conservation of momentum principle to solve collision problems in physics, or telling students to check the units, neglect small terms, or use crude approximations.

Means-end analysis

Probably the most common and general heuristic is the ‘means-end analysis’. Simply stated, this heuristic says to do something to get a little closer to the goal. This heuristic helps break down a problem into pieces. For example, the ultimate

goal is taken in short term goals and each of these short term goals will have to be achieved and doing so helps the person to get closer to the goal and ultimately reach it.

If a large problem is broken down into pieces, it is important to self monitor the sub goals, that is whether the person has achieved it or not. This self-monitoring is known as meta-cognition. Meta-cognition is essential for any extended activity, especially problem solving, because the problem solver needs to be aware of the current activity, of the overall goal, the strategies used to attain the goal and the effectiveness of those strategies.

Working backward

This strategy starts with the goal state and the operator moves backward toward the initial state. This strategy is found to be very useful in solving problems like paper-pencil maze. Sometimes the problem solver uses this method by combining it with the means end analysis. However, working backward is useful only when the end state is uniquely well defined with an unclear initial state.

Analogies

Heuristic of analogy uses experiences of strategies used to solve past problems in solving a current problem. This strategy relies on discovering common attributes among various problems solved at previous occasions and the problem being faced presently.

4.3.5 Factors Affecting Problem Solving

Effectiveness of a problem solving behaviour is measured on two criteria: time taken in solving the problem and probability of getting the solution. An effective solution of a problem is dependent upon a number of factors. Some of these factors are inherent in the problem itself, while others belong to the personal characteristics of the problem solver. These include (i) Nature of the problem (ii) Degree of difference between the initial and the goal state (iii) The perceiver's set (iv) functional fixedness. These are being discussed below:

i) Nature of the problem

What is themagnitude of the problem, the difficulty level of the problem etc. are part of nature of the problem. Also if the initial state of the problem is too different from that of the final goal of the problem the difficulty level increases and solving the problem becomes somewhat difficult. While size of a problem is positively related with the number of elements present in the problem space, it is observed that as the size of the problem increases, it becomes all themore difficult to reach solution to the problem and also it becomes more time consuming. An example is the typical anagram problems, where an increase in the number of letters of the anagrams enhances the difficulty level of the problem.

ii) Greater the difference between initial and goal states decreases the likelihood of solution. In such situations problem space is more disorganised and therefore, the operator is required to take more steps to reach to the solution. To give an example, take a complete jumble of letters in an anagram which clearly describes such a situation.

If the problem is a general one which is frequently encountered, the problem solver becomes familiar with the steps to be followed to reach the solution and therefore, the problem becomes less difficult.

iii) The perceiver's Set is defined as a tendency to perceive and respond to a particular stimulus in a stereotypical manner. Set is formed in a situation where a person successively and systematically perceives and responds to a stimulus in a similar way. Set may prove to have facilitatory, as well as inhibitory impact on problem solving.

If the past experience paved the way to the formation of certain mental set, then the solution will become easier. But in case of greater difference among the experiences, the mental set would hinder finding solution to the problem. An example of the effect of set may be observed by pronouncing the following words:

MACDONALD MACMOHAN MACGREGOR MACHINERY

If you pronounced the last word as MacHinery, the effect of set worked on you. However, the effect of set can be minimized by increasing time interval between practice and trial, by explicit instruction to not follow the previously learned rules and by introducing some exceptions in the practice.

iv) Functional fixedness: Generally we categorise objects on the basis of their use in our daily life. Whenever we think of those objects their functional features dominate our thought process. Functional fixedness refers to the tendency to perceive the objects with their customary and stereotypical use.

In a broader sense, functional fixedness is also an example of mental set, which hinders the probability to achieve solution.

Self Assessment Questions

1) Define the problem solving behaviour.

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2) Describe the terms related to problem solving.

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3) Explain the various types of problems.

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4) Give an account of the strategies used in problem solving.

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5) Describe the factors affecting problem solving.

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4.4 LET US SUM UP

Creativity is defined as a goal directed thinking which is unusual, novel and useful. Such a thought process rejects the previously accepted ideas and organises the unclear situation in new and coherent way. Investment theory states that creativity requires a confluence of six distinct but interrelated resources: intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment. Divergent thinking is thought to be a central component in any type of creative thinking. Other aspects of creative thinking are: fluency, flexibility, originality, elaboration, abstraction and resistance to premature closure. Creativity follows a four step process consisting of preparation, incubation, illumination and verification. Although creativity requires a minimum IQ of 120, but beyond that level relationship between intelligence and creativity is either not clear or is very weak. Most of the tests of creativity intend to measure divergent thinking. Such a widely used test is TTCT which includes both verbal and figural items.

Problem solving is another kind of directed thinking that begins with an obstacle or a difference between initial state and the goal state. The person is required to reorganise the problem situation to remove the obstacle and convert the problem state into then goal state. A successful understanding of problem space requires coherence, correspondence and relationship to background knowledge. Types of

problems referred in the psychological researches are well-defined and ill-defined problems, problems of inducing structure, transformation and arrangement. Cognitive psychologists have described two major types of strategies used in problem solving: algorithms and heuristics. The factors affecting the success of problem solving behaviour include the size of the problem, difference between problem state and goal state, generality of tje problem and set and functional fixedness of the problem solver.

4.5 UNIT END QUESTIONS

1) Define the process of creativity and describe that how different psychologists differ in understanding creativity.
2) Explain that how Investment and Confluence Theory of approaches creativity and present an account of aspects of creative thinking.
3) Briefly discuss the stages of creativity.
4) Describe that how creativity is related with intelligence and explain the threshold hypothesis in this regard.
5) Give an account of measurement of creativity.
6) Define the problem solving behaviour and describe the terms related to problem solving.
7) Explain the various types of problems and present an account of the strategies used in problem solving.
8) Describe the factors affecting problem solving.

4.6 GLOSSARY

Creativity : Creativity is a goal directed thinking which is unusual, novel and useful.

Historical creativity : Historical creativity is a creative thinking that becomes so important that it influence the whole human civilisation.

Investment theory : Investment theory states that creativity requires a confluence of six distinct but interrelated resources: intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment.

Threshold hypothesis : The hypothesis that state that a minimal level of IQ, often arbitrary set to 120 should be necessary, but not sufficient for creativity.

Problem solving : The directed thought process involved in a person's effort to remove obstacles in the way to achieve the goal state is called problem solving.

Well-defined and ill-defined problems : A problem is well-defined if there is a definable initial state and a goal state, the number of operators is definite and they all are well identified and there are quite explicit rules and

sub-goals to convert the initial state into the goal state. On the contrary, in case of ill-defined problem one or all of the elements of the problem space (initial state, goal state, operators and rules) are not clearly defined.

Problems of inducing structure : Problems of inducing structure require determining relationship among several elements of the problem.

Problems of transformation : Problems of transformation require finding a sequence of operations to transform the initial state into the goal state.

Problems of arrangement : Problems of arrangement requires the operator to rearrange the elements of the problem according to some criterion.

Strategy of problem solving : A strategy is a set of sequential steps (or procedure) used by a problem solver in arriving at a solution.

Algorithm : An algorithm is a strategy that ensures the correct solution of the problem, if the well-defined rule of the solution is properly followed.

Heuristics : Heuristics are general suggestions or "rules of thumb" that are useful in solving a great variety of problems but do not ensure a correct solution to the problem.

Set : Set is defined as a tendency to perceive and respond to a particular stimulus in a stereotypical manner.

Functional fixedness : Functional fixedness refers to the tendency to perceive the objects with their customary and stereotypical use.

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