CHAPTER III

INTELLIGENCE AND ITS MEASUREMENT

In the previous chapter, we have reviewed the development of intelligence tests. But one question that has still remained unanswered is "what do we actually mean by 'intelligence'." In the present chapter, an attempt has been made to discuss, at length, the nature of intelligence and what the so-called intelligence tests measure.

Despite the common use of the term 'intelligence' and similar terms such as 'clever' and 'ingenious', we know little about the concept of intelligence. Even psychologists are not clear in defining it. They have thought much about it, and both the teacher and the layman frequently use the word. Many times arguments end in a vicious circle, with some one saying that intelligence is what an intelligence test measures. It is because of the vagueness of the nature of intelligence that many do not have faith in the measurement of intelligence by intelligence tests. It is, therefore, necessary to know the connotation of 'intelligence' with a view to discovering to what extent intelligence tests should be considered a fair measure of a person's

innate intellectual potentiality. So the purpose of this chapter is twofold:

(i) to elucidate the concept of intelligence, and

(ii) in the light of this, to find out what so-called intelligence tests measure.

The concept of intelligence is a matter about which there is a wide divergence of opinion. It may seem strange that it should be possible to measure, even approximately, something whose fundamental nature is differently defined by different persons. But as Rex Knight puts it:

> But there is no real inconsistency here any more than there is inconsistency in the fact that electricians can measure the strength of an electric current when they are unable to define electricity.[1]

For the practical purpose of measuring intelligence, it may well be that full knowledge of its nature is unnecessary. Terman is no doubt right when he says that:

> To demand that one who would measure intelligence should first present a complete definitions of it is quite unreasonable.[2]

Psychology is a Science and a Science is not

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1 Rex Knight, Intelligence and Intelligent Test, London, Methuen and Co.Ltd., p. 8.

2 Ibid., p. 5.

meant to serve practical purposes alone. The study of the nature of intelligence is an important part of the Science of Psychology, just as the study of the nature of electricity, though possibly of little use to engineers is an important part of the Science of Physics.

Definitions of Intelligence

Definitions of intelligence have been offered throughout the history of philosophy. But we are concerned only with the meaning of the term in the field of psychology and education during the past half a century. Below are given some important definitions of intelligence:

(1) Binet

> To judge well, to comprehend well, to reason well, these are the essential activities of intelligence.[3]

Binet's approach has sometimes been referred to as a 'global' approach. The ultimate purpose of intelligence according to Binet was the continuous adjustment of the individual to his environment, accomplished as the result of an organization in which several mental functions (comprehension, invention, direction and criticism) are involved.

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3 Remmers and Gage, Educational Measurement and Evaluation, New York, Harper & Brothers Publishers, p. 196.

(2) Terman

> Intelligence is the ability of the individual to think in terms of abstract ideas.[4]

This definition is purely theoretical, confining intelligence to abstract thinking. It is clear that Terman's definition excludes practically all young children, and for that matter, excludes a vast percentage of adults from the realm of intelligence, for sheer abstraction is a phenomenon rarely met in human intelligent responses. Moreover, as Spearman points out, it excludes concrete thinking as a factor of intelligence.

Rex Knight also points out four serious objections to Terman's definition of intelligence:

(i) It implies that intelligence cannot be manifested at the level of perceptions. But the fact is that intelligence is clearly involved in perceptual tests.

(ii) He does not state that in order to exhibit intelligence, the abstract thinking, must be relevant to some questions or aim.

(iii) It assumes that the capacity for abstract

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4 Ibid., p. 197.

thinking is simple and indivisible, whereas it is a compound ability comprising more than one power.

(iv) The capacity for abstract thought like all other abilities, involve factors, specific to itself as well as intelligence, and therefore to identify it, with intelligence is a mistake.

(3) Colvin

"The ability to learn to adjust to one's environment".

This definition does not analyse or explain what is meant by intelligence. It identifies intelligence with the ability to learn to adjust to one's environment. The trees for example adjust themselves to various seasons. So according to Colvin's definition trees have intelligence.

(4) Thorndike

> We may define intellect in general, as the power of good responses from the point of view of truth or fact.[5]

In this definition, Thorndike uses the words 'truth' and 'fact'. These two words present more questions

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5 Ibid., p. 197.

than the term which is being defined. What should we mean by 'truth' and 'fact'? These two words have been debated since many centuries and to explain intelligence from the point of view of 'truth' and 'fact' is only making intelligence itself more confusing.

(5) Sandiford

"It is a function of central nervous system."

Thus, to Sandiford, 'mind', 'consciousness', 'reasoning', 'imagination', 'thinking', really stand for certain type of bodily behaviour, that is to say every state of mind can be reduced to some form of behaviour of neurons. One fails to understand the reason for doubting that mental processes occur. Another objection as pointed out by Rex Knight is that 'if mental processes are identical, with cerebral processes we could never be aware of any of our mental processes without being aware of the physiological processes in our brain.'

(6) Cyril Burt

"Inborn all-round mental ability."

This definition does not give us the exact meaning of intelligence. It seems that this definition supports the monarchic view of intelligence which regards intelligence as an all-pervading mental power. Johnson seems to

have believed in such a definition, declaring that Newton could have written a great epic if he had turned his mind to poetry rather than Mathematics. If his definition is accepted we can infer that a person, who performs one intellectual task well, will do others equally well. This is far from the fact.

A close study of these definitions reveals that some definitions of intelligence, like Terman's are purely theoretical, confining intelligence to abstract thinking while others like Binet's are descriptive rather than definitive. While there are considerable differences in the definitions of intelligence, it should be noted that they differ in the emphasis on one or the other aspect of intelligence. It is clear from the foregoing discussion that the intellectual ability of an individual is not a clear-cut entity which can be pinpointed as intelligence. Those who define intelligence as an ability to carry on abstract thinking or ability to adjust are not doing justice to the comprehensive nature of this concept. It is this inadequacy of words to define anything so basic and complex as intelligence that has caused many psychologists to resort to the statement that intelligence is whatever the intelligence tests measure. As P.E.Vernon of London University says, "these psychologists, although they have been testing intelligence with some success for over forty years, have failed

to reach any agreed definition as to what they are measuring." Ballard aptly says:

> While a teacher tried to cultivate intelligence and a psychologist tried to measure intelligence, nobody seemed to know precisely what intelligence was.[6]

Despite these differences with regard to the definition of intelligence, it is possible to group all the views in some categories. Ballard has grouped them in three categories, viz:

(i) those that regard intelligence as a single ability common to all intellectual processes;

(ii) those that regard it as a group of two or three abilities of varying degrees or generality; and

(iii) those that regard it as representing no real entity but as merely a convenient term for the average of all specific abilities.

Perhaps the most comprehansive attempt to define intelligence has been made by Stoddard. According to him:

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6 Ballard, P.B., Op.Cit., p. 23.

> Intelligence is the ability to undertake activities that are characterised by (i) difficulty, (ii) complexity, (iii) abstractness, (iv) economy, (v) adaptiveness to a goal, (vi) social value, and (vii) the emergence of originals, and to maintain such activities under conditions that demand a concentration of energy and a resistance to emotional forces.[7]

Stoddard discusses each of these attributes of intelligent activity at length. His main point is that all these attributes must be present simultaneously, we must not achieve difficulty merely through the gravity of a task:

> 'Difficulty' is measured by percentage of passing; 'complexity' by number of kinds of tasks; 'abstractness' by distance from the physical, explicit, and complete; 'economy' by speed of accomplishing mental tasks; 'adaptiveness to a goal' and 'social value' by the activity's utility for satisfying the individual's and society's needs; the 'emergence of originals' by the newness and uniqueness of intellectual products. The more a given activity has all these attributes, the more intelligence it demands. None of the ingredients can be lacking.[8]

Theories of Intelligence

Mental testing went on merrily for some time before some one asked the awkward question, "What is

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7 Remmers and Gage, Op.Cit., p. 198.

8 Ibid., p. 199.

intelligence?" Most people assumed the truth of what Spearman calls the monarchic view, believing in the "sovereign rule of one great power" - intelligence in all mental operations. If the view that intelligence is all-pervading mental power is accepted then we can infer that a person who performs one intellectual task well, will do others equally well. All psychologists, however, have not subscribed to the monarchic view. The "Oligarchic doctrine" - as it is called by Spearman, teaches that one mental ability consists not of one, but a few great powers each requiring a separate measurement. The oligarchic view was crystallized in the older faculty psychology which was rendered obsolete by the experiments of William James, Some held the more extreme view that is the anarchic view. They said that there are as many abilities as there are human functions and all these abilities are independent of one another and the inference regarding any one cannot be made from the performance of any other. The theory suggests that the general intelligence is the average of several abilities and is measured by sampling. If we accept this theory it will be difficult to decide which ability should be measured by intelligence tests. If the abilities are really independent, an average seems to be meaningless.

I. <u>Faculty Theory of Binet</u>

He regards General Intelligence as a complex

mental quality involving at least three factors:

(i) The ability to comprehend a problem and the due direction of the mind towards it.

(ii) The capacity to make the necessary adaptations to the need of the situation.

(iii) The power for self-criticism.

This faculty theory of Binet has been exploded and has been replaced by better theories given by later psychologists. They no longer believe that mind is made up of several faculties.

II. Spearman's Concept of Intelligence

Spearman's two factors theory dates back to a paper published in 1904. He was interested in the correlations between abilities. If abilities were correlated they had a common factor:

> All branches of intellectual activity have in common one fundamental function(or group of functions), whereas the remaining or specific elements seem in every case to be wholly different from that in all the others.[9]

This first statement of the famous 'two factor' theory of intelligence was arrived at from a study of inter-correlations. If a battery of tests be used, a table of inter-

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9 American Journal of Psychology, Vol. XV, p. 284.

correlations can be calculated. If now the high correlations are placed at the head of the table and the low ones at the bottom, a hierarchical order is seen. The table of correlations shows a consistency which Spearman regards as significant. Those tests which have high correlations also have relatively high correlations with each of the individual tests. The central factor common to all abilities tested he called 'general intelligence' or 'g'. Every ability has also a specific factor 's' which unlike 'g' is unique for that particular ability. Factors 'g' and 's' are, however, unrelated. Any given ability can be divided into two parts - a common 'g' and a specific 's'. The ratio of 'g' to 's' differs for different abilities.

It will be seen that the 'g' factor probably represents general ability or general intelligence the thing which intelligence tests measure with some degree of success. It is relatively constant for the same individual but varies greatly from individual to individual. It is the common element, 'g', which makes the measure of an individual in a number of traits exhibit positive correlation. The second factor 's' represents the specific factor inherent in the act of performance under consideration. It represents musical performance and mathematical ability in mathematical performance and these two 's's may be markedly different in amount in the same individual. But a person's success

in any form of response or performance is the joint product of his 'g' and 's', his ability in general and his specific ability for the task in question.

The nature of 'g' and its identification with general intelligence are still disputed. To begin with, Spearman himself is not clear whether 'g' can be called intelligence at all. However, he asserts that the best tests of intelligence are those which are rich in 'g'. Apparently he means that 'g' and intelligence are identical. Although Spearman does not define intelligence, he considers intelligence to be like energy or force which can be transferred from one mental operation to another. Wechsler and Spearman agree on the mathematical aspect of 'g' but not on the psychological aspect. Thus 'g' determines to a certain extent what an individual is capable of, and variations in the amount of 'g' in different individuals show variations in intelligence. However, whatever might be true of the nature of 'g', it has proved useful in the measurement of intelligence.

If a, p, b, q denote four abilities and rap, rbq, raq, rbp the coefficients of correlation between the various pairs denoted by the suffix, then:

$$r_{ap} \times r_{bq} - r_{aq} \times r_{bp} = 0$$

This relation Spearman calls tetrad equation, the

quantity on the left being tetrad difference; and it is well to remember that the truth of the equation depends, not on theory, but on experimentally observed fact.

Spearman calls his doctrines of the two factors "eclectic" because it includes the amount of truth in each of the three doctrines, already described before. The monarchic view is justified if we regard 'g' a constitutional monarch, a big factor in the state but not the sole one. The anarchic view holds with specific factors, for they are like free, independent, individual citizens. The oligarchic view is true to the extent that 'faculties' distinct from universal factor, and fairly distinct from the specific factors, are revealed in the broad 'group' factors.

Criticism of the Two Factor Theory

Spearman's most active critics were Thorndike and Thomson. They showed that group factors enter the picture of intelligence and that the tetrad equation may be interpreted in some other way. The technique of factorial analysis was developed and group factors such as verbal ability (v), word fluency (w), numerical ability (N), spatial ability (s), perceptual ability (p), reasoning (R) and memory (M) were found out. These valuable suggestions made Spearman himself to take up the work again and he showed that the abilities could be analysed. It gives the large

general factor and smaller group factors.

Godfrey Thomson has offered another explanation of the tetrad difference. According to him:

> Any activity such as mental test calls upon a sample of bonds which the mind can form, and that some of these bonds are common to two tests and cause their correlation.[10]

As for the possession of bonds he believes in individual differences, maintaining at the same time:

> Some are rightly endowed by heredity, some by opportunity and education, some by both, some by neither.[11]

This bond theory criticises the tetrad difference and thinks it to be a mathematical dream. It, however, accepts the presence of 'g'. The supporters of this theory and Thomson himself seem ambiguous in their criticism when they state:

> The sampling theory neither denies nor asserts general ability, though it says that it has not been proved, nor does it deny specific factor on the other hand, it does not deny the absence of group factors.[12]

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10 Thomson, G.H., The Factorial Analysis of Human Ability, London, University Press, 1950, p. 45.

11 Ibid., p. 54.

12 Brown and Thomson, Essentials of Mental Measurement, London, Cambridge University Press, 1940, p. 189.

III. Thomson-Sampling Theory of Mental Organisation

Thomson did not agree with Spearman's Two Factors Theory. He preferred to think that a number of factors are at play in carrying out any activity and these factors are the sample of all those which an individual has at his command. He has illustrated this with the data from dice throws how various factor patterns could result from overlapping samples of independent elements. The reason why this theory is preferred is that it makes fewer assumptions than more special forms of the theory. Moreover, in Thomson's own words, "It does not deny the general ability, for if the samples are large, there will, of course, be factors common to all activities. On the other hand, it does affect the general ability if the samples may not be so large as this and no single factor may occur in any activity."

IV. Thorndike - a Single General Factor Theory

Thorndike does not agree with the theory of Spearman. He says there is nothing whatever common to all mental functions or to any part of them. He admits that there is a positive relation between desirable single traits in a single individual. "Having a large measure of one good quality increases the probability that one will have more than the average of any other good quality." According to

him there are three main types of intelligence:

(1) Intelligence for words and abstract ideas.

(2) Motor intelligence or skill with use of hands.

(3) Social intelligence or the ability to get on well with one's fellows.

V. Group Factor Theories of Hull and Kelley

A group factor is one which is common to only a group of activities; it is narrower in extent than the general factor and broader than specifics. According to Hull and Kelley, who after critical analysis of the methodology and data of Spearman, said that the general factor is of relatively minor importance. The major relationships among tests be attributed to a relatively small number of broad group factors, chief among these are manipulation of spatial relationships (k), facility with numbers (n) and verbal material (v), and memory and mental speed.

Various modifications of group factor theories have appeared. Thrustone identifies himself with some form of Group Factor Theory. According to him, there are four main mental factors that are of major importance in our daily lives. They are the general factor (g), the practical factor (f), the number factor (n) and the verbal factor (v).

VI. Hierarchical Group Factor Theory by Burt

Burt classifies abilities into three distinguishable types according to their range: (i) General ability entering into every test belonging to a certain broad genus. (ii) Special abilities, each limited to certain groups or species, and (iii) Individual or specific abilities, each peculiar to a single test. Thus the whole set of factors could apparently be arranged in a rough hierarchical scheme.

This theory has, of late, been championed by Vernon. He has recently attempted to provide content to the hierarchical classification proposed by Burt. General intelligence 'G', is the only factor which he accepts. After the removal of 'G', he says, "Tests tend to fall into two main groups: the verbal Numerical Educational, on the one hand, (which he refers to as av:ed)" and "The Practical -Mechanical-Spatial-Physical, on the other, (which he refers to as the k:m factor)". If the analysis is sufficiently detailed, these types themselves subdivide. This theory is at present more a hypothesis than an established fact. As such it should be accepted, with certain reservations, in the guidance and the test construction by practical psychologists in relation to other theories mentioned above. All the main theories of intelligence examined here have important implications for guidance and test construction.

VII. Thurstone's Concept of Intelligence

This theory was recently proposed by Thurstone. By means of an elaborate type of factor analysis Thurstone arrived at the conviction that intelligence is made up of nine "primary mental abilities" as follows:

(i) Visual or spatial ability;
(ii) Perceptual ability;
(iii) Numerical ability;
(iv) Logical or verbal relations ability;
(v) Fluency in dealing with words;
(vi) Memory;
(vii) Inductive ability;
(viii) Deductive ability; and
(ix) Ability to restrict the solution of a problem.

His view is that ability in any particular activity such as understanding an article on atomic energy, solving problems in engineering, writing poetry, or selling refrigerators, or learning to do any of these activities, depends upon a combination of the nine primary mental abilities. Some of the primary abilities are more essential and function more extensively in certain skills than in others. For example, numerical ability, visual and spatial ability, and inductive ability might be more essential in learning to be an engineer than in learning to write poetry.

In the latter, fluency in dealing with words and perceptual abilities might be of outstanding importance.

Thurstone's primary mental abilities are general in the sense that they enter in some degree into all cpmplex intellectual activities, but they are not regarded as types of energy as in Spearman's view. This theory assumes that the components of intelligence can be more definitely isolated than seems to be believed by Thorndike. In fact, Thurstone feels that prediction and guidance based on knowledge of all the nine primary abilities, each considered by itself and in relation to the others, will be more fruitful than actions based on a single test of intelligence in general.

In fine, it is not possible to decide the relative validity and usefulness of these major theories. As Gates, Jersild, McConnell and Challman say, "the ultimate psychological or physiological explanation of intellect is a problem for future research by specialists."[13]

What Intelligence Tests Measure?

We notice the important fact that, however, much opinions may differ about the ultimate nature of intelligence, there is, to quote Macrae, 'close agreement as to the

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13 Gates, Jersild, McConnell, and Challman, Educational Psychology, New York, The MacMillan Company, p. 224.

procedure by which intelligence may best be measured.' Spearman, as we have seen, regards intelligence as the general factor that enters into all our cognitive abilities; Thomson doubts whether there is any such general factor; and Binet declared that 'the mental faculties of each subject are independent and unequal'. Nevertheless, the tests constructed by these three psychologists resemble one another closely.

Some people suggests that, 'because minds cannot be placed between callipers or poured into burrettes, they must be completely immeasurable.' But this is a mistake, Attempts have been made to analyse this complex trait and now there is a remarkable agreement among different psychologists with regard to the nature of principal factors involved in the process of constructing and standardising intelligence tests. The main factors isolated have been named as:

(i) Verbal Ability (v);
(ii) Verbal Fluency (W),
(iii) Numerical Ability (N);
(iv) Spatial Ability (S);
(v) Perceptual Ability (P);
(vi) Memory (M); and
(vii) Inductive Reasoning (R).

A proper test would contain items judging these factors, at all levels of difficulty.

There are various problems that beset the researcher in the preparation of a test of intelligence. The main question is, do intelligence tests measure what we call intelligence? Or do they measure only abilities that are environmental? The heredity environment issue is another problem which has taxed the brains of many. The advocates of heredity push their claims in the make-up of intelligence, while the advocates of environment believe that environment goes a long way in the development of one's intellectual potentialities. In this controversial discussion, the Canadian psychologist Hebb has struck a practical note on the concept of intelligence. He has made a distinction between intelligence A and intelligence B. According to Hebb, there exists in an individual an innate, immeasurable, genetic potentiality which is the property of the brain and the central nervous system. This capacity Hebb describes as intelligence A, whereas intelligence B is the final product of intelligence A, as developed by environment. Thus intelligence A grows, but this growth is conditioned by age and environment (stimulating or otherwise). Intelligence B is wider in its connotation. It covers various abilities such as reasoning, understanding, and abstract thinking.

Thus, it is very difficult to separate pure native intelligence from acquired knowledge. Pure abstract -

intelligence does not exist. It always requires a vehicle on which to ride. These vehicles are of various kinds. As there is no unanimity of opinion with regard to the number of different vehicles to be used and their relative importance, the tests differ according to the stress laid by the research -er. This native intelligence cannot be measured unless manifested in behaviour. Two persons, born with the same amount of intelligence but brought up in different environmental conditions, one given the best opportunities while the other, denied even the contact with the world, will, in spite of their equivalent innate capacities at birth, be found to differ widely, if tested by any of the available good tests of intelligence. The difference, however, cannot be attributed to the tests. Two persons given the same opportunities of environment and schooling are tested by a good test of intelligence. They are found to differ widely in their test performance. The difference in their performance can be attributed, to a large extent, to the difference in native intelligence. Binet frankly accepted knowledge as one of the marks of intelligence.

Thus the amount of knowledge and training that is measured for gauging the degree of innate ability is that which is based on the elements appealing to common interests; and within the common experiences of the children tested. Knowledge presupposed by intelligence tests is nothing more

than what normal children, under normal conditions of home and health are bound to acquire from their day to day experience. Let us take one item from Binet's scale for example. The child is to find out absurdity in the given statement.

"Yesterday there was a railway accident. But the newspaper says, it is not a serious one, as only forty-eight people were killed." To answer this correctly, knowledge gained from daily experience only, is to be expected. So this can be included in a test of intelligence. But a question like, 'who is the finance minister of India' or 'what is the chemical formula of hydrochloric acid?' cannot be used as an item of an intelligence test.

What abilities should be examined in a particular test depends upon the emphasis the test constructor puts on particular abilities in his own concept of intelligence.

Intelligence tests measure abilities such as reasoning, critical thinking, and verbal and numerical abilities. It is, therefore, possible that one individual subjected to two intelligence tests may show different scores. As we have seen, psychologists differ in their emphasis on various aspects of intelligence. Thus two intelligence tests may differ, and so also may the scores of the same individual in two tests vary.

The Present Investigation

As discussed in the previous pages, it is very difficult to decide the relative validity and usefulness of the major theories. It is not wise to think of accepting any one definition or theory and then to construct tests which may suit it. In framing the present test, however, Spearman's concept of intelligence was kept in view. The test, therefore, is based on the assumption that the best tests of intelligence are those which are rich in 'g'.

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