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1. Learning Outcomes

After studying this module, you shall be able to:

- Briefly define Intelligence
- Understand how intelligence tests are constructed
- Understand the standards of intelligence testing
- Understand the impact of cultural bias on intelligence testing
- Understand how heredity and environment exert influence on the development of intelligence.

2. Introduction

Humans require the use of intelligence in every aspect of their daily lives. From practical to emotional to social and many more such areas. Every individual varies in his or her cognitive abilities in comparison to other people. So, can we say that individuals differ on the basis of intelligence they possess? If it is so, then how these individual differences on intelligence are measured? How is an intelligence test constructed and what standards do scientists require to consider an intelligence test good? How does cultural bias influence the individual differences in intelligence? Moreover, what do various studies reveal about the role of heredity and environment in the development of intelligence? In this module, we would find answers to all such questions. In this discussion, we will focus on various researches made in the field of intelligence, which would help us better understand the concept of its measurement and heredity and environment's role in its development.

3. Define

Researches have been made, theories have been developed since past one hundred years, and still the most agreeable definition for intelligence remains undiscovered. But, to give a brief description about what intelligence is, we would dwell on the following definition of intelligence, "*Intelligence is an individual's ability to learn from his or her experiences, attain knowledge from those experiences and then use that knowledge to deal accordingly with his or her environment*".

Think of a situation in which you have to choose between a bicycle and a car, by which you would be travelling to a place 2 km away. Now, choice of the mode of transport which you make requires the use of practical intelligence. Consider another situation in which, you see a stranger crying on the roadside. Here, your emotional intelligence works

up to make you empathize with that stranger. Think of one more situation in the examination hall, where you get a question which seems unfamiliar with your preparation. You might try all the methods you know to solve that question and might end up with a solution. Thus, we require intelligence on a daily basis to make choices, solve problems, and establish bonds with others and much more. Intelligence is therefore, a very crucial part of every individual's cognition, which has been understood as not a single ability but, a global capacity of distinct intellectual abilities. However, every individual perceives same situations differently and may use their intelligence in different ways to cope with daily-life problems. This gives rise to a question, how can we measure these differences in intellectual abilities? The following section will shed some light on the same question and help us understand how intelligence is measured.

4. Measurement of Intelligence

Let us consider the above mentioned situations and see how individuals use their intelligence to get across each of them. One person might choose a car and the other might choose the bicycle to travel a distance of 2 km. Also, one individual might reach to the weeping person and empathize with him and the other individual might not reach up and just go away. Similarly, one might be able to solve the unfamiliar question in the question paper and others might not be able to. So can we say that those who are able to find a solution are more intelligent than others, or those who opt for a bicycle and those who empathize with the weeping person are more intelligent than those who opt for car and do not empathize with the weeping person? Measurement of intelligence would be a better option to answer such questions.

4.1 How can intelligence be assessed?

One way to understand this complex phenomenon of intelligence is to assess it with the help of intelligence testing. **Intelligence Testing** refers to the estimation of people's intellectual ability through their performance on various tasks or test papers designed to assess the mental competencies. Thus, **Intelligence Test** is a series of tasks designed to measure a person's ability to think rationally, act purposefully and deal effectively with different situations. The score derived from the assessment of an intelligence test is known as an **Intelligence Quotient (IQ)**, which is a term coined by psychologist William Stern in the early years of 1900s.

The first intelligence test was invented by French psychologist Alfred Binet (1857-1911) in the early years of 20th century, with an aim to discover the children with special needs in learning abilities and help them cope with the school curriculum. In 1905, Binet and his colleague Theodore Simon upgraded Binet's intelligence scale and named it **Binet-Simon Test**. This revised version was computed while taking into consideration every student's chronological age because children's mental competencies advance as their age increases over time. In 1916, Stanford University psychologist Lewis Terman revised the Binet-Simon test and produced the **Stanford-**

Binet intelligence scale, which became most popular in the USA for a number of years. This test defined intelligence in terms of four distinct cognitive abilities:

- Verbal reasoning (i.e., the ability to solve verbal problems)
- Quantitative reasoning (i.e., the ability to solve arithmetical problems)
- Abstract/Visual reasoning (i.e., the ability to solve problems which include geometric shapes with complex relationship)
- Short-term memory (i.e., the ability to preserve sensory information in the working memory, for a short period of time)

Two decades later, psychologist David Wechsler developed a test which proved to be a strong competitor to the Stanford-Binet test. Wechsler believed that intelligence should be measured as group of distinct but related intellectual verbal and non-verbal abilities, which Stanford-Binet did not emphasize on. Therefore, he developed distinct tests for adults and children which measured both verbal and non-verbal abilities. Wechsler Adult Intelligence Scale (WAIS) was developed in 1939, followed by the development of Wechsler Intelligence Scale for Children (WISC) in 1955 and later, the development of Wechsler Preschool and Primary Scale of Intelligence (WPPSI) in 1967. Since then, Wechsler scales have been the most widely individually administered intelligence tests in the USA.

Intelligence Quotient (IQ): Intelligence quotient was a term coined by psychologist William Stern, to define the score derived from the assessment of the intelligence test. Lewis Terman used this concept to develop the Stanford-Binet test. Stern's (1912) formula of IQ was to divide the **Mental Age (MA)** by the **Chronological Age (CA)**, which is the number of years passed since birth, and multiply the result by 100 to get rid of the decimal points. The final result is called the **intelligence quotient** or **IQ**.

$$IQ = MA/CA \times 100$$

For example, a person who is 20 years old takes the intelligence test scores a mental age of 15 years old (i.e., he is able to answer questions which are up to the level of a 15 year old), so his IQ would be:

$$IQ = 15/20 \times 100 = 75$$

The Intelligence Quotient allows us to compare the intelligence levels of people of different ages.

Intelligence tests are widely used in the western societies to make important decisions such as those related to education, occupation and clinical decisions. Such tests have become an important tool for cognitive psychologists, who seek to measure the cognitive development, stability and change over a period of time.

4.2 How are intelligence tests constructed?

Methods of Reliability	Meaning
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To design an intelligence test, the first and foremost need is to decide which specific behaviours serve as indicators of the mental competencies we desire to assess. Next arises a need to decide the items that would allow us to assess those behaviours. Last but not the least, there is a need to collect the evidence regarding the validity of the tests (i.e., our sample of items are actually measuring the mental competencies which our test aims to measure). Now the question arises of how to meet these requirements, the answer to which lies in the following key concepts of measurement:

- Reliability
- Validity
- Standardization

Let's take a hypothetical example to understand this concept of test construction. For example, a Professor Martin, believes that an elementary class student's (i.e. 10-16 years of age) intelligence is determined by his or her vocabulary or verbal ability. Now, in order to test his hypothesis, Martin must construct an intelligence test measuring the verbal ability of elementary class students. As he has already decided the specific behaviour which serves as an indicator of mental competencies, his next requirement would be to devise the items to assess the verbal ability. His last requirement would be to collect the evidence ensuring the validity of the test, for which the sample items of his test must measure the verbal ability of the students. Let's understand how Professor Martin meets all these requirements.

Reliability refers to the *consistency of the test results*. A test is considered to have higher reliability if it produces similar results under consistent conditions. In other words, a test is considered to be reliable if it reveals similar results each time it is taken by the same person or group of people under similar situations.

Thus, in case of Professor Martin's test, his test would be reliable if it produces the same result regarding their verbal abilities, each time he gives it to the same person or group of people under similar conditions.

There are three types of methods used to measure reliability (table 1).

Test-retest reliability	Reliability is assessed by correlating the scores obtained by the same group of people on two separate occasions, over time.
Internal reliability	Reliability is assessed by measuring the correlation among the items of the test; higher correlation indicates higher reliability.
Interjudge reliability	Reliability is assessed by correlating the judgement of different scorers for the same test or event.

Table 1: Types of Reliability and their meaning

- **Test-retest reliability** is assessed by correlating the scores obtained on the same test by the same group of people on two separate occasions, over time.
A test is given to a group of people and after some hours or days, that test is again given to the same group of people and the two set of scores so obtained are correlated. Higher correlation among the sets indicates higher reliability.
- **Internal reliability** is assessed by measuring the correlation among the items of the test. It simply refers to the consistency of measurement within the test itself. Higher correlation indicates higher reliability.
- **Interjudge reliability** is assessed by correlating the judgment of different scorers for the same test. It simply refers to the consistency of judgement when different scorers score the same test or event. Higher correlation indicates higher reliability.

Validity refers to the extent to which a test measures what it aims to measure. A test is considered to be valid if it appropriately measures the mental competency it is designed to measure.

Thus, in case of Professor Martin's test, his test would be valid if it actually measures the verbal ability of the students for which it is designed.

There are three types of methods used to measure validity (table 2).

Methods of Validity	Meaning
Construct validity	It measures the extent to which the test actually measures the psychological construct it is constructed to measure.
Content validity	It measures the extent to which the items of the test measure all the skills that are assumed to underlie the psychological construct it is designed to measure.
Criterion-related validity	It measures the extent to which the scores on the test successfully predict some future behaviour, which is assumed to be affected by the psychological construct, which the test is designed to measure.

Table 2: Types of Validity and their meaning

- **Construct validity** measures the extent to which the test successfully measures the psychological construct (verbal ability, in Martin's example) it is designed to measure. A correlation is measured between the test scores and behaviours other than the one being measured. Lower the correlation, higher is the validity of the test.
- **Content validity** measures the extent to which the items of the test (items measuring the verbal abilities of students, in Martin's example) successfully measures the psychological construct it is designed to measure.
In Martin's example, the content validity would measure the extent to which the items of his test measures the verbal abilities of elementary class students.
- **Criterion-related validity** measures the extent to which the scores on the test successfully predict some present or future behaviour, which is assumed to be affected by psychological construct being measured by the test.
In Martin's example, the criterion-related validity would measure the extent to which the test scores of the students successfully predict their future behaviour, which is assumed to be affected by their verbal abilities, which the test is designed to measure.

It is important to note here that, if a test is reliable, it might or might not be valid. But, if a test is valid, it is definitely reliable.

Standardization refers to a two-fold process, which means it has two aspects: (1) development of norms and standards and (2) consistent methods of test administration. The first aspect of standardization is **norms**, which refers to the test scores derived from a large sample of the target population for which the test is designed. These norms help in providing a meaning to the so obtained IQ score by the test taker. The second aspect of

standardization is the **consistent methods of test administration**, which refers to the method which is used to administer the test on a person or a group of people and which remains same despite of whosoever is the examiner or test giver.

The norms which are collected from a sample population form a **normal curve or distribution** (see fig. 1), in which the scores are most frequent around the *mean*, and become less frequent as we move away from the mean.

Normal Curve and the Stanford-Binet IQ Scores

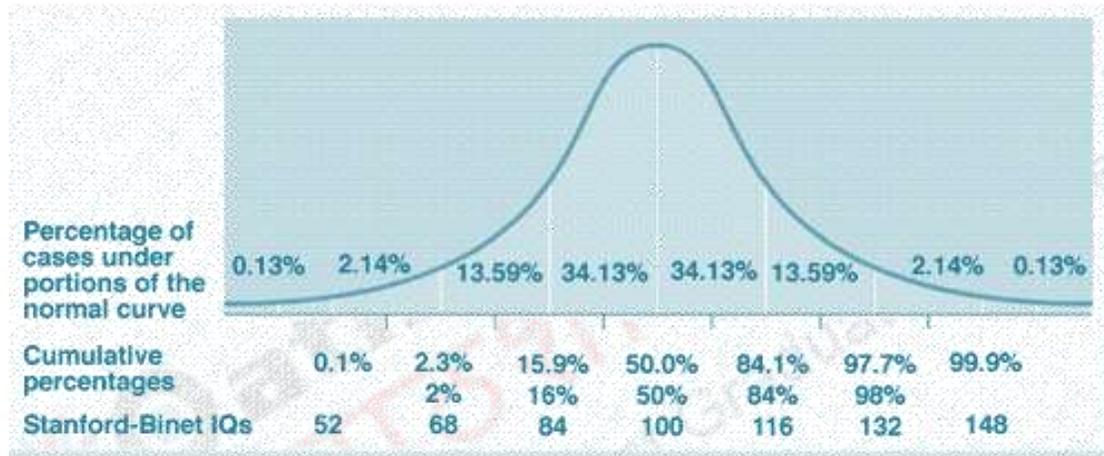


Figure 1: The Bell Curve of Intelligence

Thus, figure 1 shows an IQ score of 100 cuts the distribution into two equal halves, where equal percentage of population score above and below this mean score. The extreme points of the distribution indicate the higher and lower scores obtained by fewer people.

Deviation IQ: Since the formula of IQ had a few drawbacks such as, comparison across same age group was not possible with the IQ scores, David Wechsler (1939) developed the concept of Deviation IQ, which explains the person's intellectual ability in comparison to his/her age group, represented by the deviation of his standard score from the mean. Wechsler's IQ test have a mean of 100 and a standard deviation of 15. Thus, Wechsler's intelligence scales now use the method of deviation IQ to evaluate the result of test takers.

The Flynn Effect: a remarkable discovery by New Zealand researcher *James Flynn* revealed that most of the world's population is progressively scoring higher on the intelligence tests. As a result of the Flynn effect, the IQ scores have had an increase of 28 points in the USA since the year 1910 and a same level of increase has been observed in

Britain since 1942. The influential factors lying behind such a rise are expected to be the availability of better nutrition for both males as well as females, which has led to an increased brain functioning. Other plausible explanations are today's richer and complex learning environment which has given rise to a need of complex coping abilities, and technological advances in today's era which has helped in the development of abstract and more logical thinking of individuals.

4.3 Impact of Cultural Bias on Intelligence Testing

Intelligence is a universal phenomenon studied and researched upon by various researchers. However, a great deal of challenges are faced by psychologists and researchers, who aspire to study the concept of intelligence in people across the world. People come from different cultures and socio-economic backgrounds holding entirely different beliefs and customs, in comparison to others. IQ test taken by people who are culturally very different from the person who has constructed the test, are not likely to perform well on such tests. Some people might not be aware of the language in which the test has been developed, and those people might end up with poor scores on the test. Some people are even deprived of literacy and are still underprivileged in many corners of the world till date. Such a large cultural diversity existing among the humans all over makes it difficult for the researchers to develop an intelligence test which is free of *cultural bias* i.e., it can be taken by any person irrespective of their culture.

The concept of '*Intelligence*' holds different meaning for different cultures. For example, for a highly complex and advanced culture such as the urban culture, being intelligent for a teenager might mean having knowledge about how to operate a computer. Whereas, for a simple and primitive culture such as the rural cultural, being intelligent for a teenager might mean having knowledge about how to work at farms. Thus, scores on an intelligence test assessing the knowledge about computer skills might be higher for urban kids and absolutely nil for rural kids. But, this doesn't imply that urban kids are more intelligent than rural kids.

Thus, this major drawback of culture bias makes it difficult to compare people from different cultures on the basis of their intelligence. Hence, to meet the challenges posed by cross-cultural intelligence assessment, psychologists have developed non-verbal tests so as to assess the non-verbal intellectual abilities (such as, problem solving, evaluate abstract patterns, etc.). It helps reflect the non-verbal intellectual ability of the test-taker and is not influenced by the culture. A most popular nonverbal test used to assess the eductive ability is the *Raven's Progressive Matrices*.

Another major approach taken to minimise the cultural bias is to develop intelligence tests, which contain items which uses the culture-specific knowledge and skills of the test-taker to solve them. This helps reflect the intelligence and coping and adapting ability of the test taker with respect to his or her culture. Scores so obtained on such tests predict the successful functioning of the test taker in that culture.

However, one important thing to note here is that, no intelligence test can ever be culture-free, even if it is culture fair.

5. Role of Heredity and Environment

Having learnt about how intelligence is measured and the invention and construction of intelligence testing, let's move to the most important question. Intelligence is mostly effected by which of the two: Nature or Nurture? Let's engrave for the answer in the following discussion.

Nature (heredity or genes) and nurture (or environment) both influence intelligence, working in a relationship dependent on each other (see fig. 2). Nature influences on how nurture affects the intelligence of an individual. Similarly, nurture influences on how nature affects the intelligence of that individual. Let's understand better with the help of an example.

For instance, prenatal factors such as, alcohol consumption by the mother, effects the gene-directed behaviour of the new-born baby. In this way, environment influences the effect of heredity on intelligence of the baby. Consider another example, the gene-directed behaviour of a person influences what kind of a people he chooses to be friends with, further influencing the effect of that chosen company of friends on his intelligence. In this way, heredity influences the effect of environment on intelligence of that person.

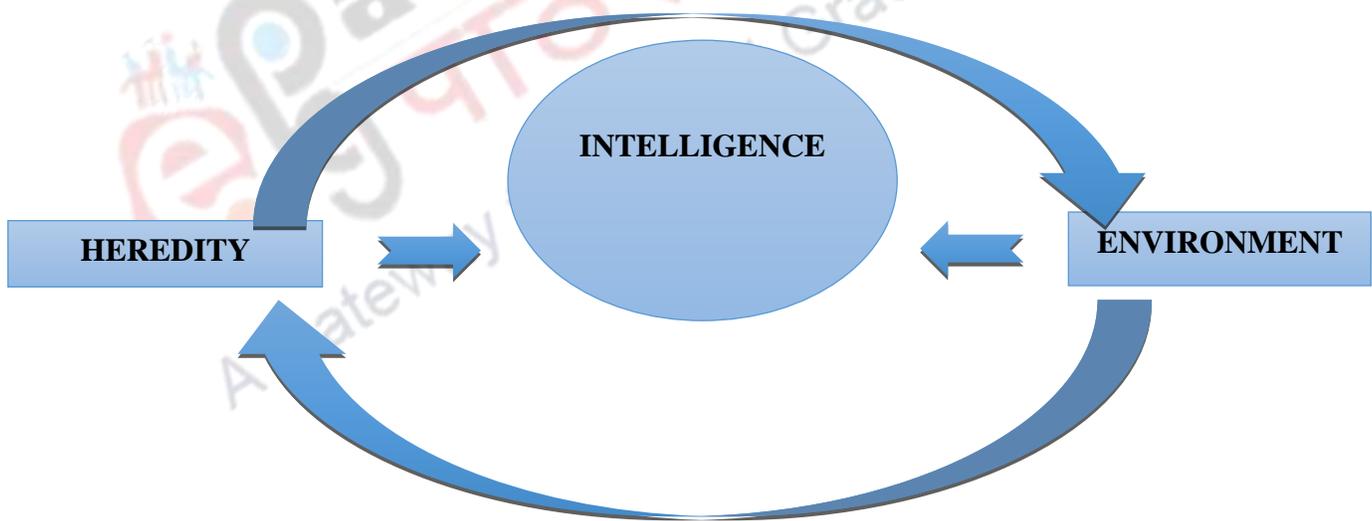


Figure 2: Interdependence of Heredity and Environment and their influence on intelligence

Thus, nature and nurture form a vicious circle, constantly depending upon each other and together influencing the individual differences in intelligence.

5.1 How do heredity and environment influence the development of intelligence?

Genetic factors clearly have a strong influence on individual's intelligence. More than two-thirds of the group variations in intelligence is due to genetic factors, as reported by research (Plomin et al., 2007). Also, the research suggests that the more the genes people have in common, the more similar IQ they tend to have. Twin studies made by various researchers suggest that identical twins (monozygotic twins) are found to have a slightly higher similarity in IQ than do fraternal twins (dizygotic twins). A plausible explanation behind the same is the availability of more genes in common in identical twins due to formation by a single zygote, and comparatively lesser genes in common in fraternal twins due to formation by two different zygotes (fig. 3).

Genetic factors become more important as we age. Reason being, genetic factors more strongly affect intelligence as more advanced cognitive processes emerge during development. Also, people select and create environment that they find appropriate according to their genetic factors. Thus, genes play important role as we develop.

Environment, on the other hand, accounts for 30-50% of individual differences in IQ. Environment can be divided into two parts on the basis of the Twin studies and researches made. Both shared as well as non-shared environment exert influence on intelligence. Shared environment refers to the family environment which both twins (identical or fraternal) share. Whereas, non-shared environment refers to the different family environment in which both twins (identical or fraternal) respectively live (fig. 4).

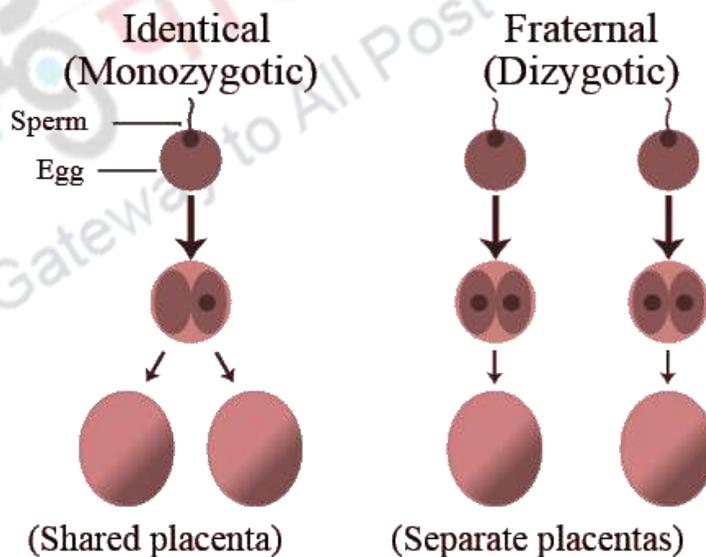


Figure 3: Identical twins tend to have slightly higher similarity in IQ than do fraternal twins

Thus, researches have suggested that shared environment have a slightly higher influence on the IQ of twins as compared to the non-shared environment. Hence, family and home environment play a major role in the development of intelligence. Identical twins raised in the same environment are likely to have higher similarity in IQ than those raised in the non-shared environment. Similarly, fraternal twins raised in the same environment are also likely to have slightly higher similarity in IQ as compared to those raised in the non-shared environment.

Socio-economic status as well as better education also play an important role in the development of intelligence.

Recall the reasons behind the Flynn Effect, which clearly states the influential role of environment (availability of better nutrition, better education facilities, technological advances and complex learning environment) on the increase of IQ scores across the globe.

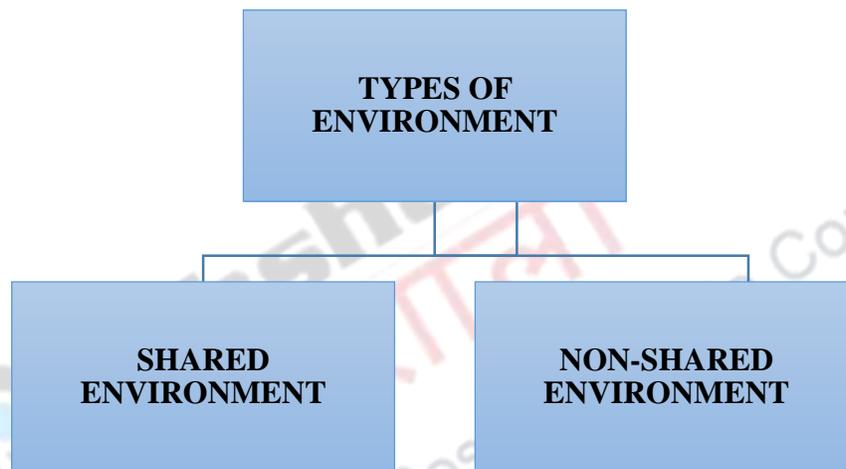


Figure 4: Children raised in shared environment are likely to have a slightly higher IQ than those raised in non-shared environment.

6. Summary

- *Intelligence* is an individual's ability to learn from his or her experiences, attain knowledge from those experiences and then use that knowledge to deal accordingly with his or her environment.
- Intelligence can be assessed with the help of *intelligence testing*, which refers to the estimation of people's intellectual ability through their performance on various tasks or test papers designed to assess the mental competencies.
- Intelligence tests can be constructed by meeting the following requirements: standardization, reliability and validity.
- *Cultural bias* leads to a difficulty of developing an intelligence test that can be administered on all people across the globe.
However, psychologists have developed non-verbal tests so as to assess the non-verbal intellectual abilities and also, they have developed specific intelligence

tests which help reflect the intelligence and coping and adapting ability of the test taker with respect to his or her culture.

However, no intelligence test can ever be culture-free, even if it is culture fair.

- Nature and nurture form a vicious circle, constantly affecting each other and together influencing the individual differences in intelligence.
- Identical twins are found to have a slightly higher similarity in IQ than do fraternal twins. Researches have also suggested that shared environment have a slightly higher influence on the intelligence of twins as compared to the non-shared environment.