South Valley University
Qena Faculty of Education
Department of Educational Psychology

PSYCHOLOGY OF INDIVIDUAL DIFFERENCESS

STUDENT'S BOOK

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Individual Differences

We, in spite of belonging to a common species known as human beings, have our own individuality which contributes towards the variation and differences found in us. It is these differences that are entitled as „individual differences" in the languages of sociology and psychology.

The differences among individuals, distinguish or separate them from one another and make one as an unique individual in oneself, may be termed as individual differences. The psychology of individual differences is concerned with the systematic study of intelligence and abilities associated with personality of learner, learning styles and needs and interests of learner.

Learning is most effective when differences in learner‟s language, cultural, and social behaviour are taken into account. A teacher should be sensitive to individual differences. A teacher‟s challenge is to acknowledge and celebrate the differences among children and work to maximize the growth in each child.

Individual Differences is the uneven rate of growth and development among individuals. It is a branch of psychology which involves the study of how and why individuals are varied in their psychological traits, as well as the outcomes of these differences. This can include examination of a range of areas such as personality traits, emotion, motivation, mood, mental health and intelligence.

Individual differences are relevant to a broad spectrum of areas which are covered in greater depth in later programme modules. For example, abnormal psychology, intelligence, developmental psychology and interpersonal relationships in various contexts. For that reason, this module provides learners

with foundational knowledge on theory, assessment and application of research in the field of individual differences.

Definition of individual difference

Carter B. Good defined individual differences as : "The variation or deviations among individual in regard to a single characteristics or a number of characteristics, those differences which in their totality distinguish one individual from another."

According **to Skinner, C.E.** "Today we think of individual differences as including any measurable aspect of the total personality.".
according to **Drever James:** "Variations or deviations from the average of the group, with respect to the mental or physical characters, occurring in the individual member of the group" .

- # Nature of Individual Differences

1. Inter-personal differences.
2. Intra-personal differences.
3. Inter-group differences.
4. Intra-group differences.

- **Inter individual differences** are the variations or distinctions that exist between different or groups of individuals. These differences can be seen across a wide range of attributes including personality traits, physical traits, cognitive abilities, and socio-cultural backgrounds. Examples of inter individual differences • Individuals may have different levels of intelligence, creativity, logical

thinking and solving abilities. • Individuals may vary in colour of skin, eyes, height, weight and other physical traits.

- **Intra Individual Differences :** are the variations or distinctions that exist within an individual over time periods. In other words, individuals may exhibit changes their behaviours, attitudes, or performance over time depending on the situation. Examples of intra individual differences • Some individuals are good in academics while others in sports. • A student may perform well in one subject but struggle in another. • An individual may have different hobbies at different stages of life.

- **Types or varieties or areas of individual differences:**

  - **Physical differences**: individual differ in height, weight, colour of skin, colour of eyes and hair, size of hands and heads, arms, feet, mouth and nose, length of waistline, structure and functioning of internal organs, facial expression, mannerisms of speech and walk, and other such native or acquired physical characteristics.
  - **Mental differences :** People differ in intellectual abilities and capacities like reasoning and thinking, power of imagination, creative expression, concentration etc. On the basis of these differences they are usually classified as idiot, imbecile, moron, border line, normal, very superior and genius
  - **Difference in motor ability** : There exist wide differences in motor abilities such as reacting time, speed of action, steadiness, rate of muscular moment, manual dexterity and resistance to fatigue etc.

- **Difference in achievement Differences** exist in achievement and in knowledge even among individuals who have almost the same amount of intelligence and have been subjected to equal amount of schooling and experience.
- **Emotional differences :** In some individuals, positive emotions like love, affection and amusement and the like are prominent whereas, in some negative emotions are more powerful. Individuals also differ in the manner they express their emotions. Some are emotionally stable and mature, while others are emotionally unstable and immature.
- **Differences in interests and aptitudes** : Variations occur among the individuals in relation to the specific tastes and interests. In a similar way, people are found to have different aptitudes. Some have mechanical aptitude, while the others have scholastic, musical or artistic aptitudes.
- **Differences in Attitude:** Attitude is a little thing that makes a big difference" -Winston Churchill. **An attitude is** a particular feeling about something. It therefore, involves a tendency to behave in a certain way in situations which involves that something, whether person, idea or object. It is partially rational and partially emotional and is acquired, not inherent in and individual."

Attitude is one of the important attributes of our behaviour. Individuals are found to possess varying attitude towards different people, groups, objects and ideas. Their attitude may be positive, negative or of somewhat indifferent nature. Similarly they differ in respect of beliefs, opinions

and ideas. Some are conservative and rigid while the others are progressive, liberal and dynamic.

Components of attitude :

a. Cognitive - our thoughts, beliefs, and ideas about something. When a human being is the object of an attitude, the cognitive component is frequently a stereotype.

b**. Affective** - feelings or emotions that something evokes. e.g. fear, sympathy, hate.

c. **Conative, or behavioral** - tendency or disposition to act in certain ways toward something. Emphasis is on the tendency to act, not the actual acting; what we intend and what we do may be quite different.

Attitudes can be acquired through social learning : **Classical conditioning:** This is learning based on association when one stimulus regularly precedes another. The one that occurs first may soon become a signal for the one that occurs second. **Instrumental conditioning:** here a child plays an active role in the learning process, which ranges from receiving selective rewards or punishments to learning to hold the right views. **Modeling:** this is learning that take place when a child witness examples and models her behaviour accordingly.

Individual difference and attitude Some of the main influences on attitude formation are: 1. Teacher 2. Friends/peer group 3. Parents 4. Teaching method 5. The language itself

- **Differences in Values : Values are long-lasting beliefs about what is worthwhile and desirable**
- **Differences in self-concept :** Self concept reflects the images, considerations or judgement about one‟s abilities and limitations usually held by an individual not only projecting himself before others but also for estimating his

self in his own eyes. • Students must be made to form proper and real concept about their self so that they may be helped in their progress and development by maximizing their potentials after getting rid of evils and negative things detrimental to progress.

- **Learning differences :** Some learn more easily and are able to make use of their learning more comfortably than others. • For some, one method of learning or memorization is more suitable, while for others, a different method suits.

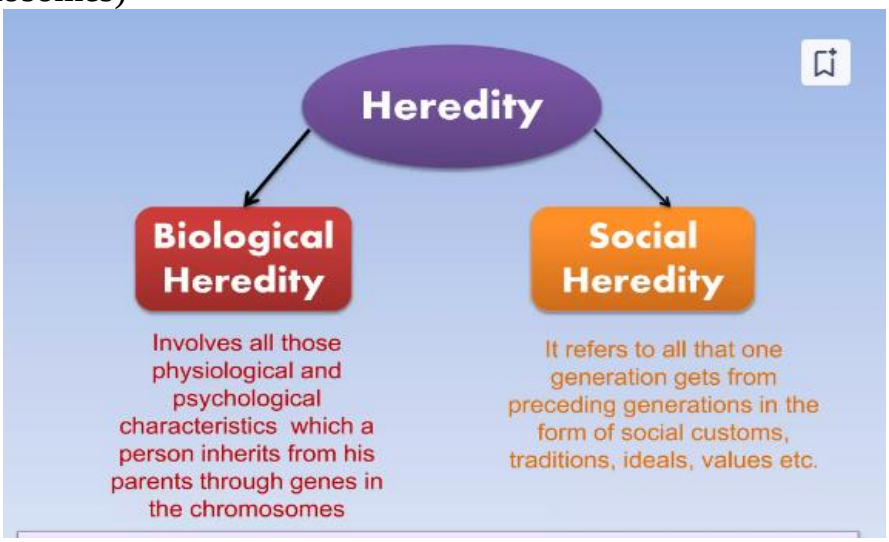
- **Different individuals have different learning styles**. Some are fast in learning the subject matter while others are slow. Some learners prefer to learn through visual aids such as videos, diagrams, charts, and models while others learn best through listening and verbal explanations. Some individuals prefer to engage in practical tasks, experiments, and real life examples.

- **Differences in study habits**: Many individual differences are found in study habits. Some are more focused in their studies while others are not. Some easily grasp the study matter while others take time to understand the concept. Some need constant guidance for their studies while others need very little or no guidance for their studies.

- **Differences in social and moral development** : Some are found to be adjusted properly in the social situations and lead a happy social life while others are socially handicapped, unsocial or antisocial. Similarly, people are found to differ in respect of ethical and moral sense.

- **Factors Effecting Individual Differences :**

A. Heredity (What occurs naturally as a function of the genes, **it is the** sum total of the physical and mental qualities that an individual inherits from his parents. These qualities are transmitted to the person from parents through genes in the chromosomes)



A. Heredity 1. Intelligence (mental ability)- Some are more intelligent than the others. And those who are more intelligent progress and grow faster than those who are less intelligent. People differ in intellectual abilities and capacities like reasoning and thinking, power of imagination, creative expression, concentration etc. • On the basis of these differences they are usually classified as idiot, imbecile, moron, border line, normal, very superior and genius Recent psychologists viewed intelligence as multiple abilities. It is necessary for a teacher to have a thorough understanding of intellectual abilities of students.

- . **A. Heredity 2. Physical condition** – It has been observed that some people are born bigger, healthier, and stronger than the others. Naturally, healthier, and stronger than the

others. Difference in motor ability • There exist wide differences in motor abilities such as reacting time, speed of action, steadiness, rate of muscular moment, manual dexterity and resistance to fatigue etc. But there are also people who are born with handicaps such as deafness, muteness, defective arms or legs, and the like. Naturally, normal people develop faster and better and are able to attain higher status than the handicapped people.

- **A. Heredity 3.Aptitude and special talent**- gifted with special aptitudes and talents in music, painting, acting, science, mathematics and the like. These children often show excellence of performance and leadership in their respective fields of specializations far above the ordinary individuals. Variations occur among the individuals in relation to the specific tastes and interests. In a similar way, people are found to have different aptitudes. Some have mechanical aptitude, while the others have scholastic, musical or artistic aptitudes.

- **A. Heredity: 4 .Sex** – Males are expected to be aggressive, fearless, and capable of doing heavier work. Females are expected to be passive, demure, prim, and the like. Hence, to a large extent, sex determines the direction of the growth and development of individuals.

- **A. Heredity: 5. Age** – age is a big factor in making one different from another. Generally , older learners have more physical strength and higher level of comprehension than younger ones. Maturation and readiness are important in learning. Mature learners have greater capacity to receive instruction.

B. Environment (What is learned and communicated in different cultures or other social groups, **It refers to** the physical surroundings and thought and attitudes of others which exert an influence on individual. Education, training, experience, nourishment and all other stimulations come under environment influence) includes Family, Socio-economic status, Culture, Previous knowledge, and experience differences

B. Environment 1. Family background – incudeslevel of education and value orientation of parents is an other determinant. If the parents suffer from ignorance and wrong values, the children likewise suffer and the adverse consequences because such parents with the right values can grow and develop more progressively than children coming from poor families. Naturally, children of affluent families can pursue higher education which is usually denied to children of poor families

- **B. Environment 2. Community** : It can be observed that children of individuals coming from these different types of communities differ markedly in their values, manners, actions, and thinking. Children coming from squatter or slum areas and from crime-infested areas have a very slim chance of growing progressively because of the bad influence of neighborhood. Barkada influence is especially strong in these places. The city children are more exposed to modern conveniences such as the telephone, television, light rail transit, museums, libraries, big commercial establishments, malls, and the like.

It can be observed also that children of individuals coming from these different types of communities differ markedly in their values, manners, actions, and thinking. The city children

has an edge over the rural children in the field of informal learning.

It is very important factors in learning and development. Good school can develop pupils better than the poor ones. There are three components make the difference between the good and poor schools. 1.Teachers 2.Facilities 3.Location

Relative importance of Heredity and Environment:

Both heredity and environment determines the personality of individual ¬ Heredity sets the probable biological limits, where as environment determines the level up to which the development is possible. ¬ Any one of two (Heredity or Environment) is equal to zero, it will have a drastic effect on the total personality Heredity deals the cards but environment plays them.

Personality = Heredity X Environment

- **C. Race and Nationality**: Race and Nationality is one cause of individual difference. Indians are very peace loving, Chinese are cruel; Americans are very frank due to race and nationality.

- **D. Sex:** Due to sex variation one individual differs from other. Men are strong in mental power. On the other hand women on the average show small superiority over men in memory, language and aesthetic sense. Women excel the men in shouldering social responsibilities and have a better control over their emotions.

- Females excel early in verbal skills while males excel in visual-spatial skills. Males are more aggressive while females are more nurturing. Females have a higher interest

in aesthetics, social service, and domestic science while males take more interest in games and sports, stories of science and bravery.

- Sex differences are related to the differences between the behaviours of males and females. Females excel early in verbal skills while males excel in visual-spatial skills. Males are more aggressive while females are more nurturing. Females have a higher interest in aesthetics, social service, and domestic science while males take more interest in games and sports, stories of science and bravery

Educational implications of individual differences…

- It is wrong to expect uniformity in gaining proficiency or success in a particular field from a group of students. On account of their subnormal intelligence, previous background, lack of proper interest, aptitude and attitude etc. some students lag behind in one or the other area of achievement. All students cannot be benefited by a particular method of instruction and a uniform and rigid curriculum.

- **Role of schools in meeting the individual differences:**

"Since we supposedly are teaching individuals, not groups of individuals, it is the function of the school within its budgetary personnel and curricular limitations to provide adequate schooling for every learner no matter how much he differs from every other learner.

- ✓ **Proper knowledge of the individual's potentialities** : The first step in making provision for the individual differences is to know about the abilities, capacities, interests, aptitudes and other personality traits of individual pupils. • For this purpose, help from intelligence test, cumulative record card, interest inventories, attitude scales, aptitude tests and measures for assessing personality traits should be taken.

- ✓ **Ability grouping :** In the light of the results derived from various tests for knowing individual differences in terms of individual potentialities in various dimensions, the students in a class or area of activity can be divided into homogenous groups. • Such division can prove beneficial in adjusting instruction to varying individual differences.

- ✓ **Adjusting the curriculum**: The curriculum should be as flexible and differentiated as possible. • It should have the provision for a number of diversified courses and co-curricular experiences. • It should provide adjustment suiting the local requirements and potentialities of the students in different groups.

- ✓ **Adjusting the method of teaching**: Every teacher should be somewhat free to formulate his own plan and strategy and adopt instructional procedure which he finds most suited to the particular types of pupils under him. • He should try to follow a different procedure or method of instruction suiting the requirements of varying ability groups of his pupils.

- ✓ **Adopting special programmes or methods for individualizing instruction :** Schools may also adopt special programmes or method of teaching like Dalton plan,

the Winnetka plan, the project method or use programmed learning material for enabling the students to learn their own individual pace.

- ✓ **Other measures of individualizing instructions:** 1. The size of the class or section should be as small as possible. 2. The teacher should try to pay individual attention the group under instruction. 3. The teacher should keep in view the individual differences of his students while engaging them in drill or practice work in classroom or assigning home task 4. In case ability grouping is not possible and more specifically under the prevalent system of class teaching, special coaching and guidance programme for both the dull and gifted children is most helpful.

Distribution of Individual Differences

It has been observed that if we collect information about people's characteristics from a large sample and examine the pattern of distribution (as shown in Fig.-3.1) we find that a large majority of the people fall in the middle range while a small proportion lies in extreme categories. For example, most of the people fall in the category of average height and very few are very tall or very short. This holds true for many more characteristics including intelligence and other psychological attributes.

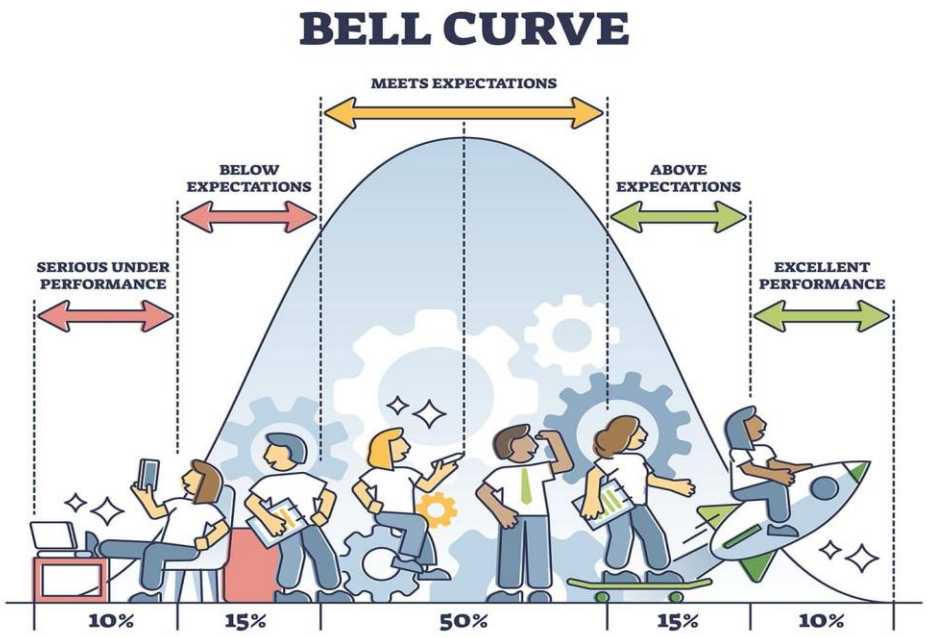


Fig. 3.1 Distribution of height of a large sample of persons

The fact that people are different from each other is a very common observation. The differences in psychological

characteristics are often consistent and form a stable pattern. By ‘consistent’, we mean that people tend to show regularity in their behavior and their patterns of behaviour do not change very frequently. This consistency and stability in behaviour is unique to every person. People develop their unique traits/characteristics and patterns of behaviour due to their genetic make up and the environment in which they are brought up. Once we know these differences systematically we can utilize the capabilities of people efficiently for their healthy development. Knowing about the specific characteristics of a person is necessary in order to extend support and utilize his or her potential to optimal level.

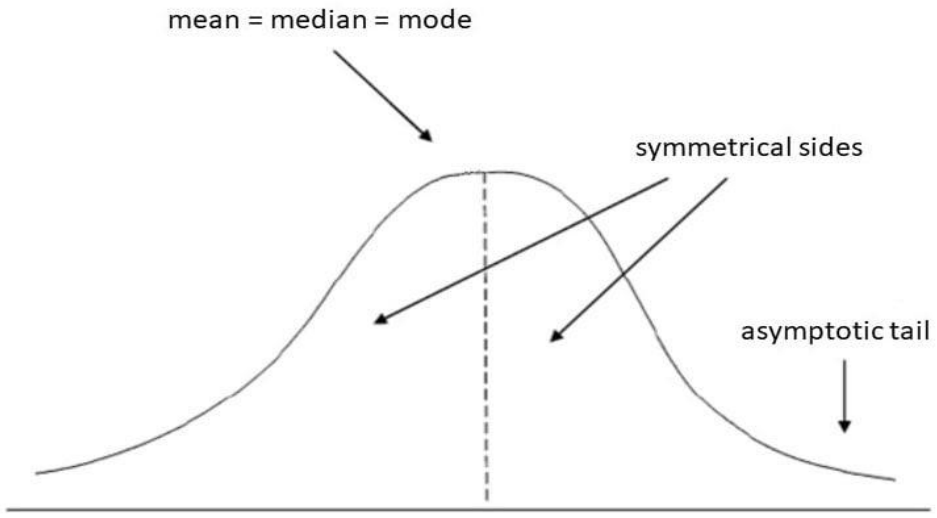
A bell-shaped curve, also known as a normal distribution or Gaussian distribution, is a symmetrical probability distribution in statistics. It represents a graph where the data clusters around the mean, with the highest frequency in the center, and decreases gradually towards the tails.

Properties Of Normal Distribution

- The normal distribution is a continuous probability distribution that is symmetrical on both sides of the mean, so the right side of the center is a mirror image of the left side.
- The area under the normal distribution curve represents the probability and the total area under the curve sums to one.
- Most of the continuous data values in a normal distribution tend to cluster around the mean, and the further a value is from the mean, the less likely it is to occur. The tails are asymptotic, which means that

they approach but never quite meet the horizon (i.e., the x-axis).

- For a perfectly normal distribution, the mean, median, and mode will be the same value, visually represented by the peak of the curve.



The normal distribution is often called the bell curve because the graph of its probability density looks like a bell. It is also known as called Gaussian distribution, after the German mathematician Carl Gauss who first described it.

Normal Distribution Vs. Standard Normal Distribution?

A normal distribution is determined by two parameters the mean and the variance. A normal distribution with a mean of 0 and a standard deviation of 1 is called a standard normal distribution.

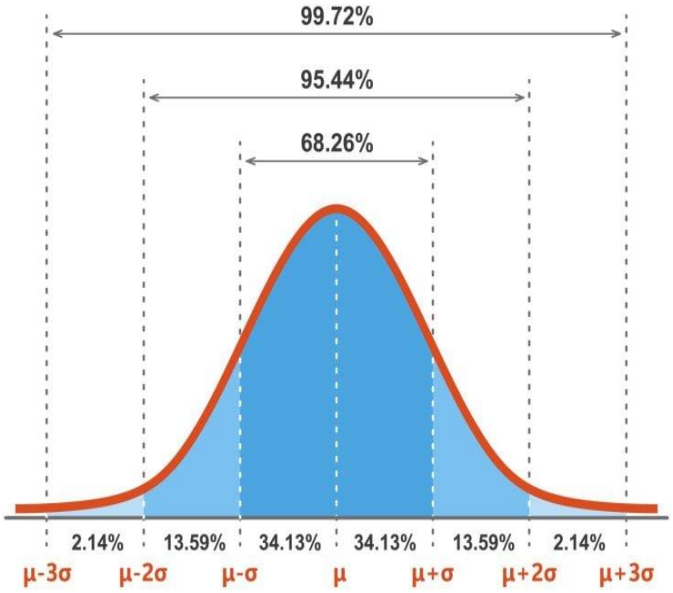


Figure 1. A standard normal distribution (SND).

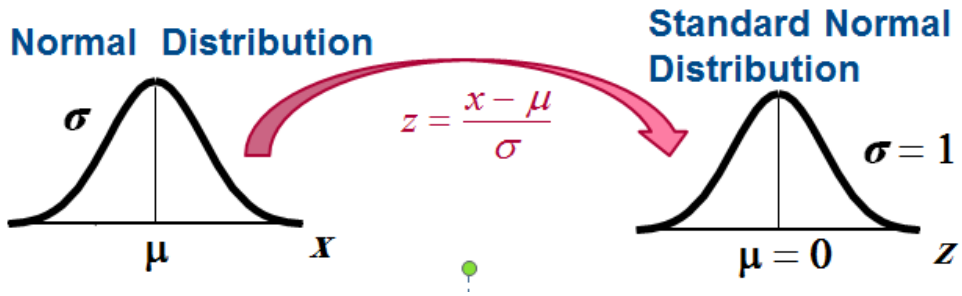
Converting the raw scores of a normal distribution to z-scores

We can standardize a normal distribution's values (raw scores) by converting them into z-scores.

- Any *x*-value can be transformed into a *z*-score by using the formula
- If each data value of a normally distributed random variable *x* is transformed into a *z*-score, the result will be the standard normal distribution.

$$z = \frac{\text{Value} - \text{Mean}}{\text{Standard deviation}} = \frac{x - \mu}{\sigma}$$

This procedure allows researchers to determine the proportion of the values that fall within a specified number of standard deviations from the mean (i.e., calculate the empirical rule).



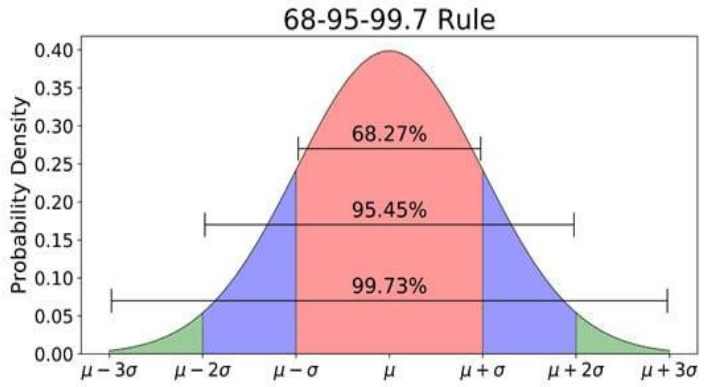
- Transforming a *z*-Score to an *x*-Score

  To transform a standard *z*-score to a data value *x* in a given population, use the formula

$$x = \mu + z\sigma$$

What Is The Empirical Rule Formula?

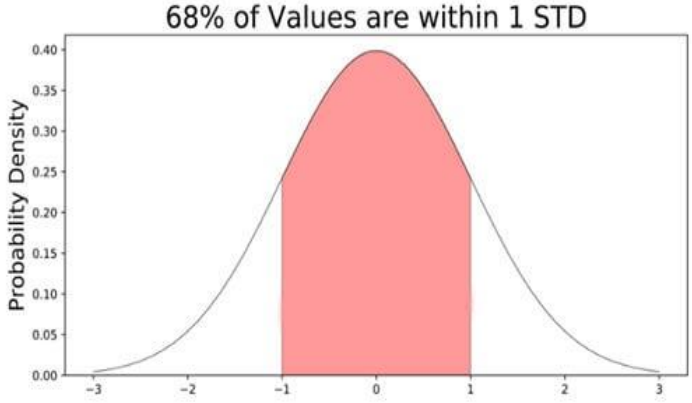
The empirical rule in statistics allows researchers to determine the proportion of values that fall within certain distances from the mean. The empirical rule is often referred to as the three-sigma rule or the 68-95-99.7 rule.



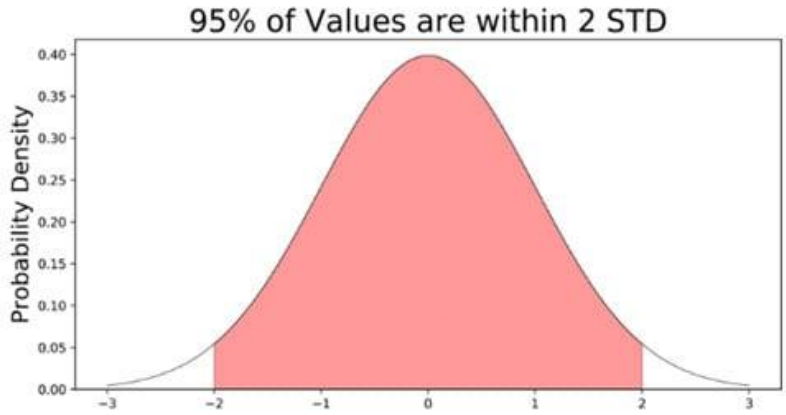
If the data values in a normal distribution are converted to standard score (z-score) in a standard normal distribution, the empirical rule describes the percentage of the data that fall within specific numbers of standard deviations (σ) from the mean (μ) for bell-shaped curves.

The empirical rule allows researchers to calculate the probability of randomly obtaining a score from a normal distribution.

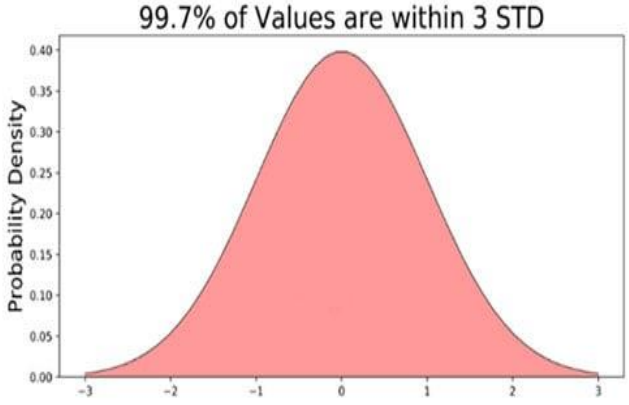
68% of data falls within the first standard deviation from the mean. This means there is a 68% probability of randomly selecting a score between -1 and +1 standard deviations from the mean.



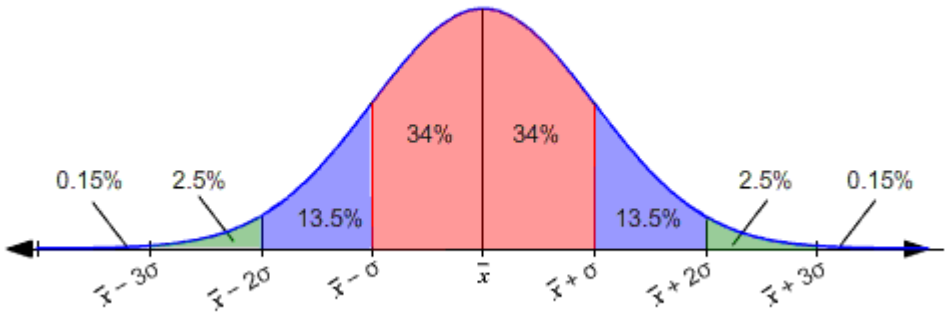
95% of the values fall within two standard deviations from the mean. This means there is a 95% probability of randomly selecting a score between -2 and +2 standard deviations from the mean.



99.7% of data will fall within three standard deviations from the mean. This means there is a 99.7% probability of randomly selecting a score between -3 and +3 standard deviations from the mean.



- In general, about 68% of the area under a normal distribution curve lies within one standard deviation of the mean.
- That is, if $\bar{x}$ is the mean and σ is the standard deviation of the distribution, then 68% of the values fall in the range between $(\bar{x}-\sigma)$ and $(\bar{x}+\sigma)$. In the figure below, this corresponds to the region shaded pink.

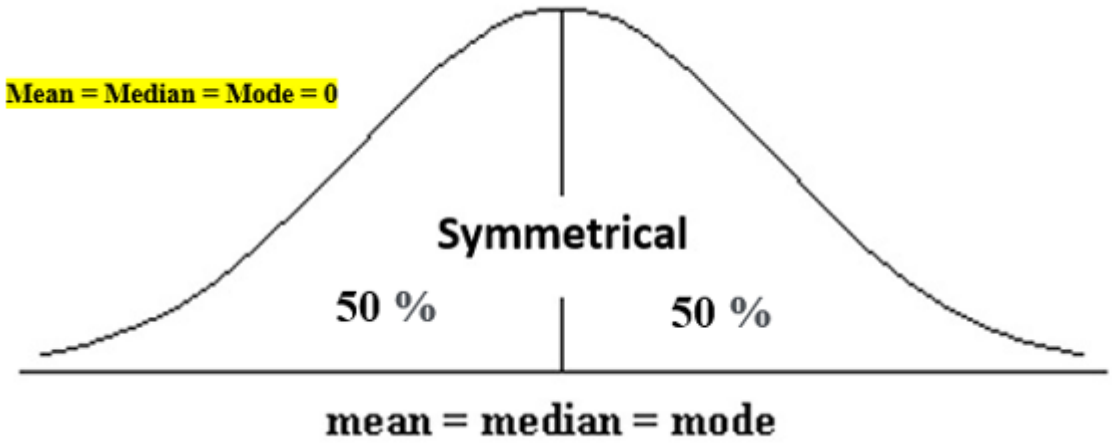


- About 95% of the values lie within two standard deviations of the mean, that is, between $(\bar{x}-2\sigma)$ and $(\bar{x}+2\sigma)$.
- In the figure, this is the sum of the pink and blue regions: 34%+34%+13.5%+13.5%=95%
- About 99.7% of the values lie within three standard deviations of the mean, that is, between $(\bar{x}-3\sigma)$ and $(\bar{x}+3\sigma)$.(The pink, blue, and green regions in the figure.) (Note that these values are approximate.)

- As for the number of individuals who fall between ($\mu + 1\sigma$) and ($\mu + 2\sigma$), as well as between ($\mu - 1\sigma$) ($\mu - 2\sigma$), it is approximately 14%.
- The percentage of extreme cases(Outliers) in both directions is approximately 2.14% of the total number of cases, and falls in the range greater than ($\mu + 2\sigma$). and less than ($\mu - 2\sigma$).

skewness

The normal distribution helps to know a skewness. When we talk about normal distribution, data symmetrically distributed. The symmetrical distribution has zero skewness as all measures of a central tendency lies in the middle.



In a symmetrically distributed dataset, both the left-hand side and the right-hand side have an equal number of observationsOf course not all test score distributions are normally distributed. They can be *skewed*, i.e. have a

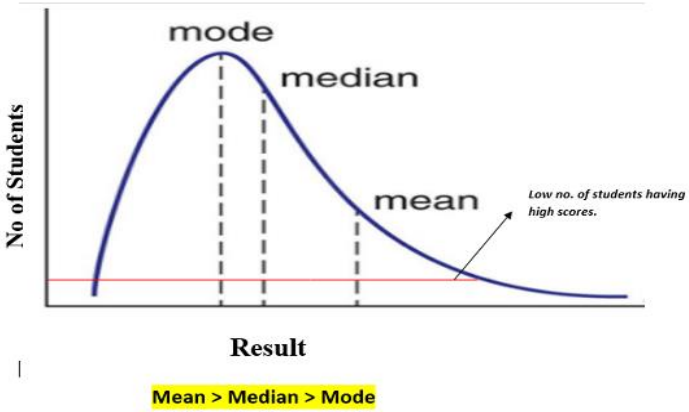
disproportionate number of people who do very well or very poorly. This would be the case if a test was too easy or too hard for the testing population. However, standardized tests are designed so that the outcome follows a normal distribution curve.

Types of Skewness

As noted above, skewness measures asymmetry in a data set and is usually shown on a bell curve. Normal distributions have zero skewness. This means that the distribution ends up being symmetrical around the mean. Having said that, there are instances where skewness isn't symmetrical. In these cases, it can be either positive or negative. Below, we highlight what each type of skewness means.

Positive Skewed or Right-Skewed (Positive Skewness)

In statistics, a positively skewed or right-skewed distribution has a long right tail. It is a sort of distribution where the measures are dispersing, unlike symmetrically distributed data where all measures of the central tendency (mean, median, and mode) equal each other. This makes Positively Skewed Distribution a type of distribution where the mean, median, and mode of the distribution are positive rather than negative or zero.

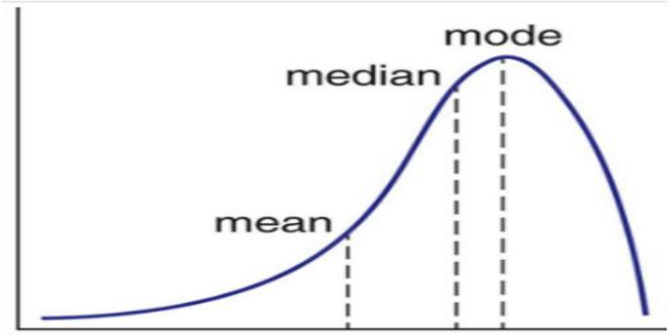


In positively skewed, the mean of the data is greater than the median (a large number of data-pushed on the right-hand side). In other words, the results are bent towards the lower side. The mean will be more than the median as the median is the middle value and mode is always the most frequent value.

Extreme positive skewness is not desirable for a distribution, as a high level of skewness can cause misleading results. The data transformation tools are helping to make the skewed data closer to a normal distribution. For positively skewed distributions, the famous transformation is the log transformation. The log transformation proposes the calculations of the natural logarithm for each value in the dataset.

A distribution with a long left tail, known as negatively skewed or left-skewed, stands in complete contrast to a positively skewed distribution. In statistics, negatively skewed distribution refers to the distribution model where more values are plots on the right side of the graph, and the tail of the distribution is spreading on the left side.

In negatively skewed, the mean of the data is less than the median (a large number of data-pushed on the left-hand side). Negatively Skewed Distribution is a type of distribution where the mean, median, and mode of the distribution are negative rather than positive or zero.



Mode > Median > mean

Median is the middle value, and mode is the most frequent value. Due to an unbalanced distribution, the median will be higher than the mean.

How to Calculate the Skewness Coefficient?

Various methods can calculate skewness, with Pearson's coefficient being the most commonly used method.

Pearson's first coefficient of skewness

To calculate skewness values, subtract the mode from the mean, and then divide the difference by standard deviation.

$$\text{Pearson's first coefficient} = \frac{\text{Mean} - \text{Mode}}{\text{Standard Deviation}}$$

As Pearson's correlation coefficient differs from -1 (perfect negative linear relationship) to +1 (perfect positive linear relationship), including a value of 0 indicating no linear relationship, When we divide the covariance values by the standard deviation, it truly scales the value down to

a limited range of **-1 to +1.** That accurately shows the range of the correlation values.

Pearson's first coefficient of skewness is helping if the data present high mode. However, if the data exhibits low mode or multiple modes, it is preferable not to use Pearson's first coefficient, and instead, Pearson's second coefficient may be superior, as it does not depend on the mode.

Pearson's second coefficient of skewness

subtract the median from the *mean, multiply the difference by 3, and divide the product by the standard deviation.*

$$\text{Pearson's second coefficient} = \frac{3\,(\text{Mean} - \text{Median})}{\text{Standard Deviation}}$$

$$\text{Mean} - \text{Mode} \approx 3\,(\text{Mean} - \text{Median})$$

Rule of thumb :

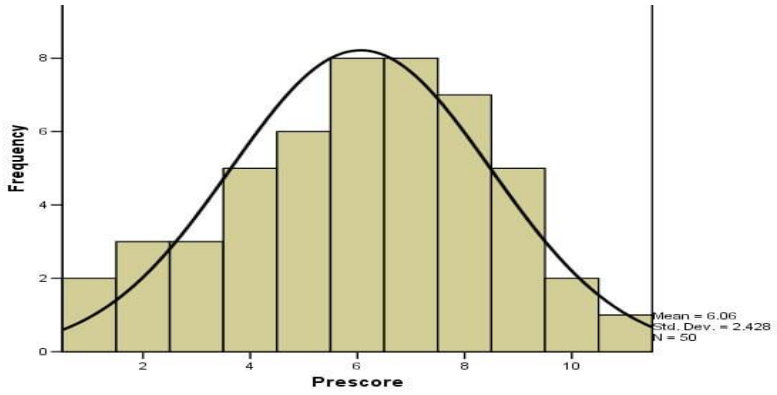
- For skewness values between -0.5 and 0.5, the data exhibit approximate symmetry.

- Skewness values within the range of -1 and -0.5 (negative skewed) or 0.5 and 1(positive skewed) indicate slightly skewed data distributions.
- Data with skewness values less than -1 (negative skewed) or greater than 1 (positive skewed) are considered highly skewed.

How To Check Data

Statistical software (such as SPSS) can be used to check if your dataset is normally distributed by calculating the three measures of central tendency. If the mean, median, and mode are very similar values, there is a good chance that the data follows a bell-shaped distribution (SPSS command here).

It is also advisable to use a frequency graph too, so you can check the visual shape of your data (If your chart is a histogram, you can add a distribution curve using SPSS: From the menus, choose: Elements > Show Distribution Curve).



Normal distributions become more apparent (i.e., perfect) the finer the level of measurement and the larger the sample from a population.

You can also calculate coefficients which tell us about the size of the distribution tails in relation to the bump in the middle of the bell curve. For example, Kolmogorov Smirnov and Shapiro-Wilk tests can be calculated using SPSS.

These tests compare your data to a normal distribution and provide a p-value, which, if significant ($p < .05$), indicates your data is different from a normal distribution (thus, on this occasion, we do not want a significant result and need a *p*-value higher than 0.05).

Tests of Normality

	Course	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Time	Beginner	.177	10	.200*	.964	10	.827
	Intermediate	.166	10	.200*	.969	10	.882
	Advanced	.151	10	.200*	.965	10	.837

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

The Normal Distribution Curve and Its Applications

The normal distribution, or bell curve, is most familiar and useful to teachers in describing the frequency of standardized test scores, how many students earned particular scores. This is not just any distribution, but atheoretical one with several unique characteristics:

- There are a number of applications of normal curve in the field of measurement and evaluation in psychology and education.

(i) To determine the percentage of cases (in a normal distribution) within given limits or scores.

(ii) To determine the percentage of cases that are above or below a given score or reference point.

(iii) To determine the limits of scores which include a given percentage of cases.

iv) To determine the percentile rank of a student in his group (The percentile rank is defined as the percentage of scores below a given score).

(v) To find out the percentile value of a student's percentile rank.

(vi) To compare the two distributions in terms of overlapping.

(vii) To determine the relative difficulty of test items,

(viii) Dividing a group into sub-groups according to certain ability and assigning the grades.

Example application:

All the second-graders in a school took an IQ testwith a mean of 100 and a SD of 15. An administrator wants to determine whatpercent of the examinees should score between 1 SD above (100 + 15 = 115 IQ) and1 SD below (100 - 15 = 85 IQ) the mean. Since the percent area under thecurve equals the percent frequency of scores, 68.26% (34.13% x 2) of thestudents should score between 85 and 115 on the IQ test. In addition, 15.87%(50% - 34.13% = 15.87%) will score above a score 115 and below 85.

On the same IQ test, one second-grader received a score of 145. The teacher knew this was an exceptional score but wanted to compare his score to those of other students. The score of 145 is +3 SD units above the mean(100 + 15 + 15 + 15 = 145). The area under the normal distribution curve to the left of this score is 99.87% (50% + 34.13% + 13.59% + 2.15% = 99.87%). Therefore, this student scored better than 99.87% of the other test-takers. This statistic is also referred to as a percentile.

Exercises:

- Given a normal distribution of 500 scores with M = 40 and σ= 8, what percentage of cases lie between 36 and 48.
- The raw score of a student of class X on an achievement test is 60. The mean of the whole class is 50 with standard deviation 5. Find the percentile rank of the student.
- A teacher records the weights of students to treat them at a clinic. The weights are normally distributed, with a mean of 39 and a standard deviation of 2. Find the weights *x* corresponding to *z*-scores of 1.96, –0.44, and 0.
- The heights of students at a college were found to follow a bell-shaped distribution with μ of 165cm and σ of 8 cm. What proportion of students are smaller than 157 cm? use the next table :

<-3	-3 to -2	-2 to -1	-1 to 0	0 to 1	1 to 2	2 to 3	>3
0%	2%	14%	34%	34%	14%	2%	0%

- The heights of students at a college were found to follow a bell-shaped distribution with μ of 165cm and σ of 8 cm. Above roughly what height are the tallest 2% of the students? use the next table :

<-3	-3 to -2	-2 to -1	-1 to 0	0 to 1	1 to 2	2 to 3	>3
0%	2%	14%	34%	34%	14%	2%	0%

- **On the same IQ test, one second-grader received a score of 145. The teacher knew this was an exceptional score but wanted to compare his score to those of other students.** (a percentile)

NATURE OF INTELLIGENCE AND ITS ASSESSMENT

In psychology, the term intelligence has been defined in many ways. One of the earliest definitions of intelligence was given by Binet and Simon in 1905 who defined it as the “ability to judge well, to understand well, and to reason well”. Binet defined intelligence as an individual’s capacity to: Find and maintain a definite direction or purpose, Adjust strategy as necessary to achieve that purpose, Evaluate or criticize that strategy so adjustments could be made. Binet and Simon used *Mental age* to distinguish “bright” from “dull” children

According to Spearman, Intelligence is the capacity of the organism to adjust itself to an increasingly complex environment. According to Terman (1916), Intelligence is The capacity to form concepts and grasp their significance.

One of the most popular definitions of intelligence was given by Wechsler (1939) who defined it as “the aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with the environment”. Sternberg (1985) Gardner defined intelligence as " the mental capacity to automatize information processing and to emit contextually appropriate behavior in response to novelty; intelligence also includes meta-components,

performance components, and knowledge-acquisition components" . Gardner (1986) defined intelligence as “the ability or skill to solve problems or to fashion products which are valued within one or more cultural settings”. He used the term ‘Multiple Intelligences’ and advocated that there are eight types of intelligences such as Linguistic, Logical-mathematical, Spatial, Musical, Bodily-kinaesthetic, Interpersonal, Intrapersonal, and Naturalistic.

Though the first attempt to measure intelligence was made by Sir Francis Galton a more systematic approach was developed by Alfred Binet, a French Psychologist. In 1905, Binet gave the concept of Mental Age (MA) which refers to an individual’s level of mental development relative to the environment in which he/she lives. Lewis Terman revised Simon and Binet’s test and published a version known as the *Stanford-Binet Test* in 1916.

The term Intelligence Quotient (IQ) was first devised by William Stern, a German psychologist, in 1912. IQ is defined as mental age divided by chronological age, and multiplied by 100:

$$IQ = \frac{MA}{CA} X100$$

For example if the mental of a child is 12 and his/her Chronological age is 8 then the IQ of the child would be 150. The intelligence test developed by Binet was

revised subsequently and in 1916 the test was given the name of Stanford - Binet test of intelligence.

One of the most popular and widely used tests of intelligence is Wechsler Scales of Intelligence. These scales have been designed for individuals of different age groups such as Wechsler Adult Intelligence Scale (WAIS) for adults and Wechsler Intelligence Scale for Children (WISC) for children between the age of 6 and 16 years. Intelligence tests are of two kinds Individual test and Group test. An individual test of intelligence can be administered to a single individual at a given time whereas a group test is administered to more than one individual at a time.

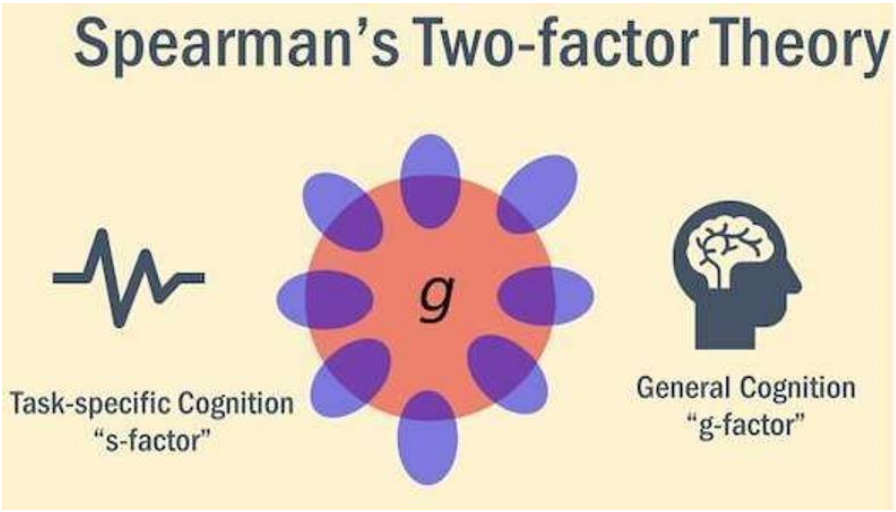
On the basis of nature of items, intelligence tests are Verbal, Non-verbal, and Performance Tests. A verbal test requires understanding of written words. Hence it can be administered to literate individuals only. In non-verbal test, pictures or illustrations are used as item of the test. Performance tests are made up of certain concrete tasks. Both non-verbal and performance tests can be administered to literate and illiterate individuals

Theories of Intelligence

Spearman's Two-factor Theory of Intelligence Explained

According to Spearman,
Intelligence is the capacity of the organism to adjust itself to an increasingly complex environment"
Various intelligence theories have been proposed by different researchers, and Spearman's two-factor theory of intelligence is also one of them. We will learn about this theory in this article.

Charles E. Spearman was a British psychologist, who was born on 10 September 1863 in London, England. He is the pioneer of a popular statistical method 'factor analysis' and is also known for his work on 'Spearman's rank correlation coefficient' and his 'two-factor theory of intelligence.' In 1904, he published his paper on 'factor analysis of intelligence' and developed his two-factor theory of intelligence.



Charles Edward Spearman proposed his two-factor theory of intelligence in 1904. He was the first who introduced the concept of general intelligence called the ”g” factor. To develop his theory, he analyzed different mental aptitude and cognitive tests given by the participants.

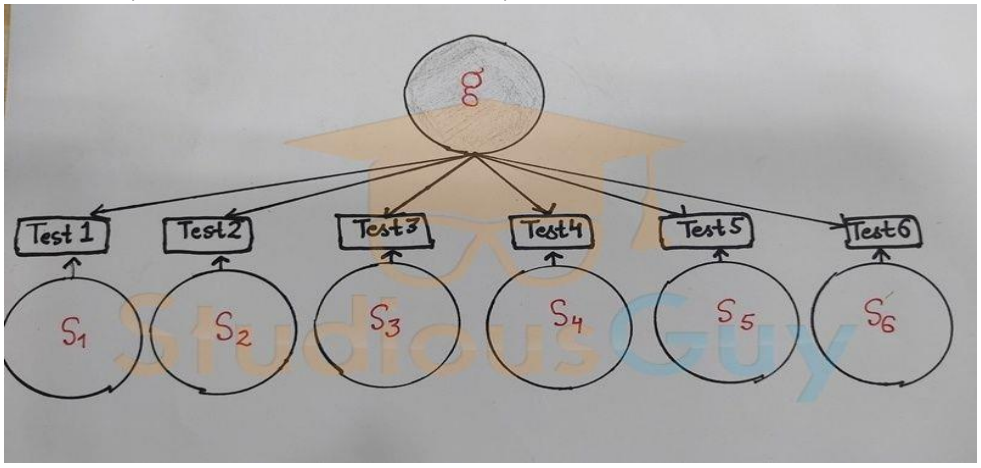
He noticed that the scores of the same participants were almost similar in every test. Those who had a good score in one aptitude test had also scored well in other aptitude tests, and those who performed badly in one test also performed similarly in other tests, which represents that there exists a factor that is common to all the intellectual and cognitive abilities of the person. Using the factor analysis technique, a technique through which various correlated variables are reduced to the lower number of factors, he examined the cognitive tests and concluded that factors related to intelligence can be measured and expressed numerically, its mathematical explanation is discussed further in this article.

Spearman stated that various mental traits are not independent of each other, and there exists a common

factor in all the cognitive abilities of the person, he called this common factor a general factor or ”g” factor.

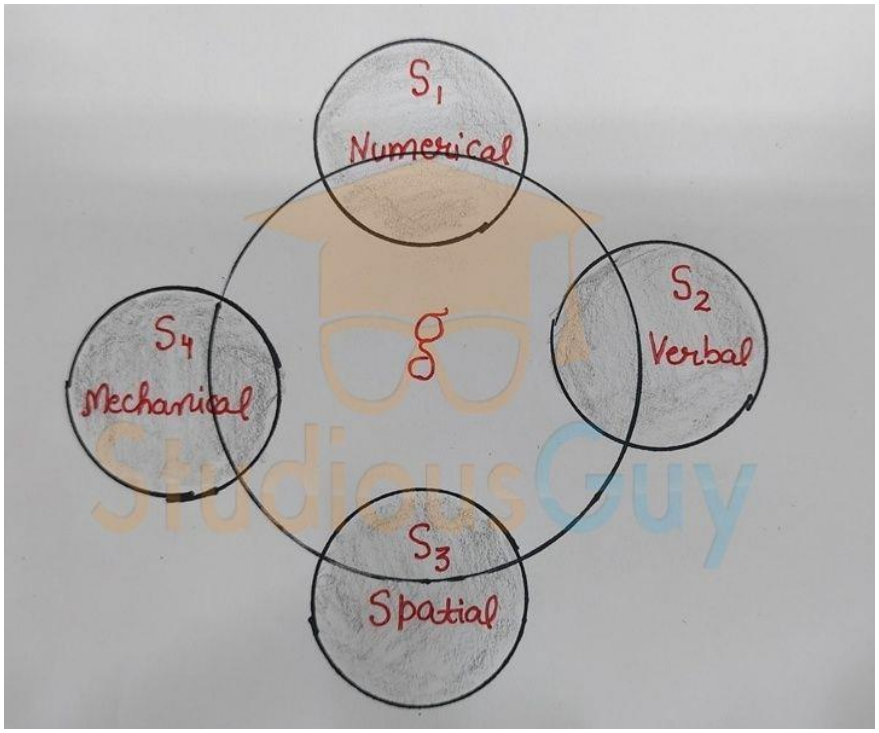
He proposed that intelligence consists of two factors, i.e., the ”g” factor (general ability) and the ”s” factor (specific ability), where the ”g” factor is involved in every general mental ability task of the person, and the ”s” factor is responsible for only the specific intellectual abilities of the person. It is to be noted that although the name of this theory is two-factor, there are more than just two factors as the s factor has various sub-factors, depending upon the number of specific abilities in each test.

It means that there are two different ‘kinds of factors,’ i.e., a general factor and specific factors. The specific abilities of a person may be drawing interference, coding abilities, mathematical abilities, and so on.



According to Spearman, every individual is born with a different level of the ”g” factor, and the greater the ”g” factor, the greater are the chances that the person will succeed in various aspects of life, whereas the ”s” factor is not inborn, people acquire this factor through experiences and from their surrounding environment. The ”g” factor is shared with every other cognitive or intellectual activity of the person, but the ”s” factor is not shared with different

intellectual activities, it's specific to a particular activity. Let us understand it with an example, consider two tests, i.e., 'numerical' and 'verbal,' which have the specific factor 'S1' and 'S2,' respectively and common factor "g," and consider another two tests, 'spatial' and 'mechanical,' having specific factors 'S3' and 'S4' respectively and common factor "g." Here, "g" represents the general ability, and "s" represents the specific abilities of the person. This can be understood from the figure given below, which shows that the "g" factor is common in all the specific factors. Spearman stated that the main purpose of the psychological tests is to measure the "g" factor of the individuals because it is the common factor in all the cognitive abilities, and every individual's intellectual abilities and performance differ based on their "g" factor.



This figure shows that the "g" factor is common in all the specific factors, i.e., S1, S2, S3, and S4.

In 1927, Spearman published his book, “The Abilities of Man,” in which he called the ”g” factor as ‘mental energy,’ and elaborated the concepts of the ”g” and ”s” factors. He stated that the degrees of the ”g” factor or general intelligence vary in every individual, and the ”g” factor of the person can not be increased upon training, but ”s” factors can be improved. Mathematically, The total intelligence score of the person (I) is the sum of the ”g” factor and ”s” factors that an individual possesses, i.e.,

$$I = g+S1+S2+S3+S4+\ldots$$

Where S1, S2, and S3 represent the different specific abilities of the person, say mechanical, numerical, vocabulary, or spatial abilities.

Note: (g) factor differs in quantity and does not differ in quality but, (S) factor is specific to the test itself, and varies in quantity and quality.

Spearman’s Two-factor theory of intelligence has a great contribution in the field of psychology as it introduced the concept of factor analyses, which is now widely used by many other researchers in their studies. An American Psychologist, Joy Paul Guilford, who is popularly known for his psychometric study of human intelligence, has stated that, 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, 1904.”

Mathematical Explanation of Spearman's Theory

Spearman developed a "correlation coefficient" to show how much a test relies on g. A correlation coefficient close to 1 or -1 means the test mainly measures g. A score near 0 means the test focuses more on specific skills. Coefficients between test pairs show how much the tests measure the same thing - general intelligence. Tests with the highest coefficients are best for measuring g.

The correlation matrix is a table that consists of systematically arranged correlation coefficients of scores obtained by the person in various mental aptitude tests. The correlation matrix is given below.

	a definitions	b problems	c classification	d antonyms	e inferences
a. Definitions	—	·56	·48	·40	·32
b. Problems	·56	—	·42	·35	·28
c. Classification	·48	·42	—	·30	·24
d. Antonyms	·40	·35	·30	—	·20
e. Inferences	·32	·28	·24	·20	—

Correlation matrix showing different correlation coefficients values of scores obtained by the participant in different tests. Here, a, b, c, d, e represent different tests.
all correlation coefficients are positive, meaning all tests share the common factor in measuring. The correlation coefficients are arranged in descending order in each row and each column of this symmetric diagonal matrix.

The ratio existing between the correlation coefficients in any two nearby columns is a fixed ratio, This phenomenon is called the hierarchical organization of correlation coefficients

Guilford (1953) showed that the proportionality between different variables can be calculated easily with the help of a correlation matrix, which makes it easy to calculate the tetrad difference between the subtests. Spearman used the ‘tetrad difference’ method to analyze intelligence. This method has been widely used in various psychological investigations; it is represented by the quantity F, and it is the difference between the cross products of two opposites coefficients of any four correlation coefficients in a square block. For example, consider four intellectual activities that are measured in the test, having correlation coefficients R13, R14, R23, R24 in the correlation matrix (nearby four in the correlation matrix), then the mathematical expression of tetrad equation would be,

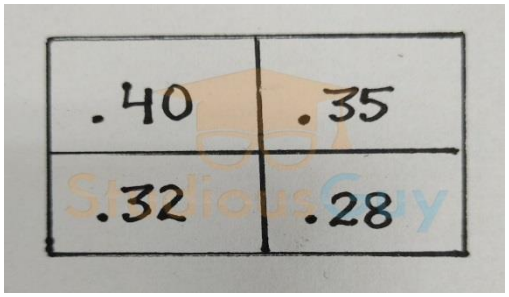
$$F=(R13)(R24)-(R14)(R23)$$

Spearman observed that the cross multiplication of any two opposite correlation coefficients in the square block (nearby four correlation coefficients) in the correlation matrix was almost equal, i.e., the value of F approximately equals zero. Hence, for the above expression,

$$(R13)(R24)\approx(R14)(R23)$$

This implies, $F\approx(R13)(R24)-(R14)(R23)\approx0$

Let’s consider the following square block from the above correlation matrix.



Four Nearby Correlation Coefficients (square block) from the above Correlation Matrix.
Here, the tetrad difference,
i.e., F = (.40)(.28)- (.32)(.35) = 0.112 – 0.112 = 0

This explains that the F value (tetrad difference) approximately or equals zero in almost all the intellectual tests, i.e., almost similar performance of the individual in the various mental aptitude tests; this represents the ”g” factor. The variation in the tetrad difference or we can say that the measured intelligence variation in different tests is due to the specific ”s” factor of the individual.

An individual shows different specific abilities in different tests. Hence, it proves that the “g” factor, i.e., the general factor is required in all the intellectual tests, and the higher the correlation between the two coefficients, the higher is the saturation of these coefficients with the “g” factor.

You can calculate the number of correlation coefficients from the following equation:

Number of correlation coefficients= N(N-1)/2

(N) = number of tests used

Relationship Between g and s Factors

According to Spearman, g and s interact in a hierarchical fashion:

- General intelligence (g) influences and overlaps with all specific abilities (s factors). Students with a high g factor will tend to perform better on tests of specific skills.
- Specific abilities (s factors) draw upon and are constrained by general intelligence (g). Students with a low g factor will face limits in how high their specific skills can develop.
- But specific skills (s factors) can also be enhanced through means that do not depend on g, like focused training and practice. This shows s factors have a degree of independence from general intelligence.
- Overall, Spearman theory of intelligence argues that both g and s contribute to intellectual capabilities. Neither general intelligence nor specific abilities alone can fully explain an individual's cognitive profile. Both factors interact in complex ways to determine a person's strengths and weaknesses.

Example of Spearman theory of intelligence

- Spearman theory of intelligence says intelligence has two parts - a general factor and specific factors. This

theory is shown in examples from daily life and test scores.

- Think of g, the general intelligence factor, like a car engine. The engine's power affects how fast the car can go. But the car still needs tires, transmission and control systems (s factors) to move. This shows both g (engine power) and s (other parts) impact performance. Neither alone decides how well the car drives. They work together.
- Look at two students' test scores. One student did better on all three tests. This means that the student likely has a higher g factor - overall mental ability. Whatever makes that student think smarter help with any topic. But scores also differ by subject. Training could boost the other student's specific math score without affecting g. But they would still struggle on other tests due to a lower g factor.
- Consider two boys playing a video game for the first time. One boy picks up the game quickly, figures out how to defeat enemies and progresses rapidly. The other boy struggles. The boy who learned faster likely has a higher g factor. His better overall mental ability helps him learn the game faster. But with enough practice and strategy advice, the second boy may eventually perform close to the first in that game.
- Examples show general intelligence influences how well a person does on any mental task. Specific abilities involve narrow skills that can be trained. g and s interact and work together to determine how well a person thinks and learns. Examples illustrates that Spearman theory of intelligence view that both general intelligence and specific abilities contribute to

intellectual capability. Neither factor alone can fully account for intelligence.

Educational Implications of Spearman's Intelligence Theory

Spearman's two-factor theory can be applied in the education sector to analyze the intellectual abilities of children.

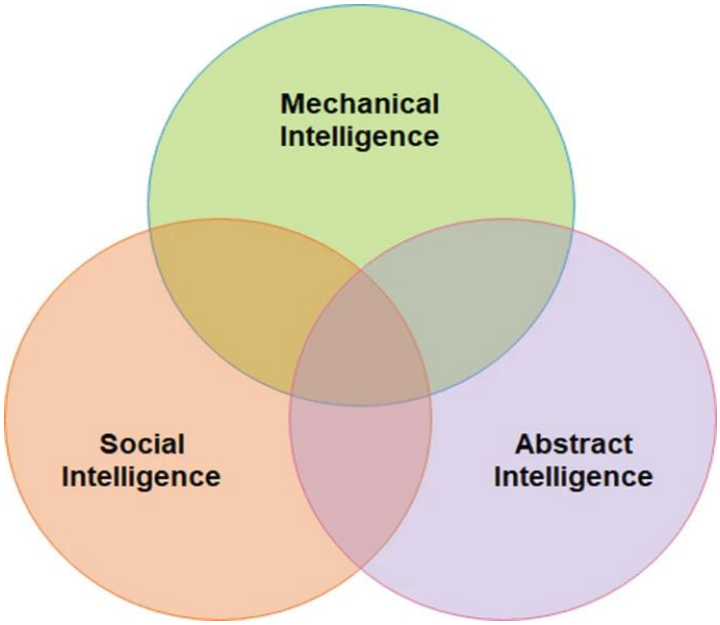
As we have discussed in this article, every person possesses different levels of "g" and "s" factors. The students need different degrees of "g" and "s" factors to perform well in different academic subjects. For example, the student's performance in mathematics could be due to his general intelligence and his specific numerical abilities, i.e., g+s1.

Similarly, in literature, it may be because of g+s2 factors, and in science, it may be because of g+s3, and so on. Since the "g" factor is common in all specific activities, the performance of the student in academics can be analyzed through their "g" factor. The "g" factor of the students can be checked through a variety of intelligence quotient tests that have a high "g" factor correlation.

As we discussed earlier, the "g" factor is inborn and can't be improved, but the performance of the students can be improved by developing their "s" factors. The schools should organize various academics and sports activities to improve the specific abilities of the students.

Thorndike's Intelligence Theory

Thorndike came up with his model in 1920, when psychology was dominated by the concept of intelligence as a universal factor. As one of the first realized significant limitations of this approach and proposed a model consisting of three mutually independent components.



Abstract intelligence or general intelligence

- It is the ability to respond to words, numbers, letters, etc. It is the ability to carry on abstract thinking.
- It is a measure of one's ability to reason and understand complex concepts and assimilate new information beyond previous experience.

- It is independent of educational and cultural background.
- Math skills are often abstract as they depend on the ability to conceptualize things without laying hands-on physical objects.
- Good teachers, lawyers, engineers, architects, doctors, philosophers, etc. have this type of intelligence.

Mechanical or concrete intelligence

- the ability to effectively control your body and manipulate objects
- It is related to concrete materials.
- This type of intelligence is applicable when the individual is handling concrete objects or machines or operation of tools or instruments .
- It includes the ability to visualize the relationship among objects and understand how the physical world works .
- Example: Engineers, Mechanics, painter, sculptor, surgeon

Social intelligence

- It is an ability of an individual to react to social situations in daily life.
- It includes the ability to understand people and act wisely in human relationships.
- People with this type of intelligence , know the art of winning friends and influence them.
- Example: Leaders, Salesman, ministers, Diplomats.

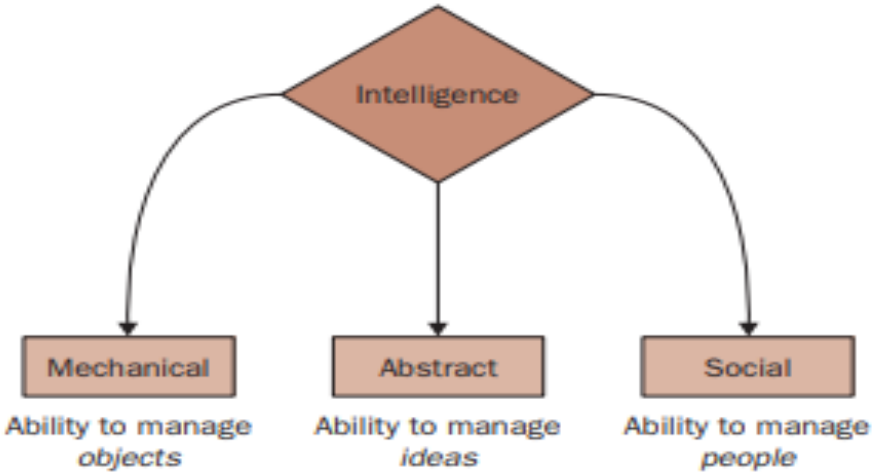


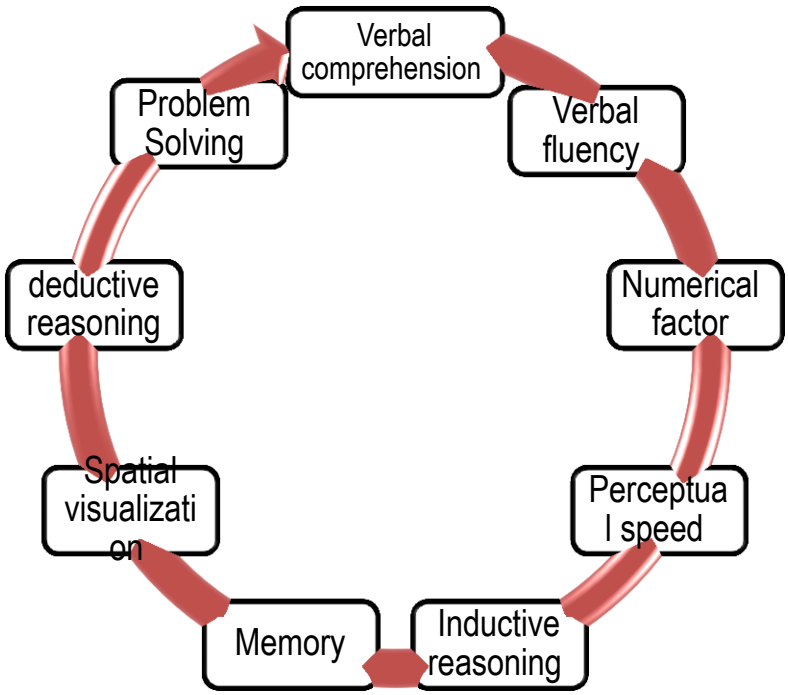
Figure 8.2 Thorndike's three intelligences, mechanical, abstract, and social.

Thurstone's Group Factor Theory

Louis Thurston came out with the group factor theory (1937) saying that Intelligence is a cluster of abilities. Using a slightly different statistical technique than Spearman used, called multiple factor analysis, Thurstone analyzed the results of 56 tests administered to 240 university students. He concluded that there were thirteen independent factors, which he called primary mental abilities. Each of these primary factors is said to be relatively independent of others.

He pointed out that there were Seven Primary Mental Abilities and later on added two more.

Nine Primary Mental Abilities:



Verbal comprehension Factor:

This factor involves a person's ability to understand verbal material. It is measured by tests such as vocabulary and reading comprehension. This factor describes the ability to do well on tests such as reading comprehension, verbal analogies, and vocabulary.

The ability to understand the meaning of words, concepts, and ideas.

- Example

  what is meant by:

  the speed of a car equals zero.

  the average speed of a moving car is 40 km/h.

- define each of the following:

The electromotive force of a battery.

The electric current

- write the scientific term of each of the following statements:

  The breaking up of bonds between molecules of the reactants and formation of new bonds between the molecules of the products.

- illustrate by balanced symbolic chemical equations the following reactions:

  The effect of heat on sodium nitrate.

Verbal fluency Factor:

This factor is involved in rapidly producing words, sentences, and other verbal material. The ability to use words quickly and fluency in performing such tasks as rhyming, solving anagrams, and doing crossword puzzles. It is measured by tests such as one that requires the examinee to produce as many words as possible beginning with a particular letter in a short amount of time.

we can develop such ability by using verbal / oral questions/presentations. There are several tests of this ability,

- Example: participants were asked to name as many words as they could that (i) began with the letter 'P' (excluding people and place names) and (ii) that belonged to the category of 'animals'.

Numerical Factor:

This factor is involved in rapid arithmetic computation and in solving simple arithmetic word problems. The ability to use numbers to quickly computer answers to problems. Found in tests measuring the speed and accuracy of simple arithmetic computations.

Perceptual speed Factor:

This factor is involved in proofreading and in rapid recognition of letters and numbers. The ability to grasp perceptual details quickly and accurately and to determine similarities and differences between stimuli. Reflects the ability to grasp visual details, similarities, and differences.

It is measured by tests such as those requiring the crossing out of as in a long string of letters or in tests requiring recognition of which of several pictures at the right is identical to the picture at the left.

- examples
- compare between:
  Oxidizing agent and reducing agent.
- how can you differentiate between each of the following:
  Silver nitrate and sodium nitrate using sodium chloride.

Inductive reasoning Factor:

This factor requires generalization—reasoning from the specific to the general. The ability to derive general rules and principles from presented information (examples) . Found in tests that require the examinee to find a rule, such as in number series completion test.

It is measured by tests, such as letter series, number series, and word classifications, in which the examinee must indicate which of several words does not belong with the others.

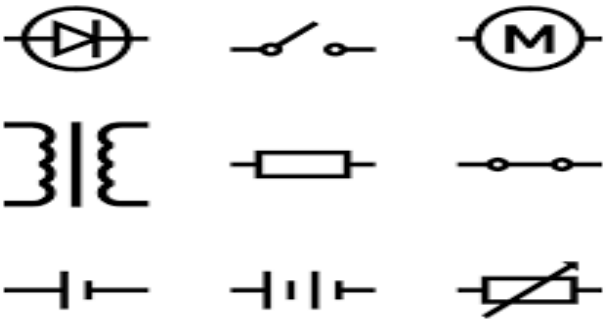
Inductive reasoning first involves the collection of data. If I add sodium metal to water, I will observe a very violent reaction. Every time I repeat the process, I see the same thing happening. I draw a general conclusion from these observations: the addition of sodium to water results in a violent reaction.

Spatial visualization Factor:

This factor is involved in visualizing shapes, rotations of objects, and how pieces of a puzzle fit together. The ability to visualize and manipulate patterns and forms in space. Measured by tests that require the visualization of geometric figures that have been rotated in space.

An example of a test would be the presentation of a geometric form followed by several other geometric forms. Each of the forms that follow the first is either the same rotated by some rigid transformation or the mirror image of the first form in rotation. The examinee has to indicate which of the forms at the right is a rotated version of the form at the left, rather than a mirror image.

Example:
study the following figures, then answer the questions:



Make a closed electric circuit using the items above to verify Ohm's law.

Memory Factor:

It means the ability to recall and associate previously learned items effectively or memorize quickly. The ability to recall information such as lists or words, mathematical formulas, and definitions. Found in tests of rote memory for word associates.

Deductive Reasoning (P):

Ability to use the generalized results correctly.

In deductive reasoning, I make a specific prediction based on a general principle. One general principle is that acids turn blue litmus paper red. If I have a bottle of liquid labeled "acid", I expect the litmus paper to turn red when I immerse it in the liquid.

Example: math

- first premise:All numbers ending in 0 or 5 are divisible by 5.
- second premise: The number 35 ends with a 5

- inference : so it must be divisible by 5.

Biology – plant classification

- first premise: Monocot flower parts are in multiples of three.
- second premise: Apple flowers have five petals.
- inference: Therefore, apple trees are not monocots.

Problem solving ability factor (PS):

Ability to solve problem independently.

- examples

- calculate the acceleration of a moving car whose speed changes from 7 m/s to 12 m/s during 2.5 sec.
- what happens when:
  Putting a piece of sodium in water

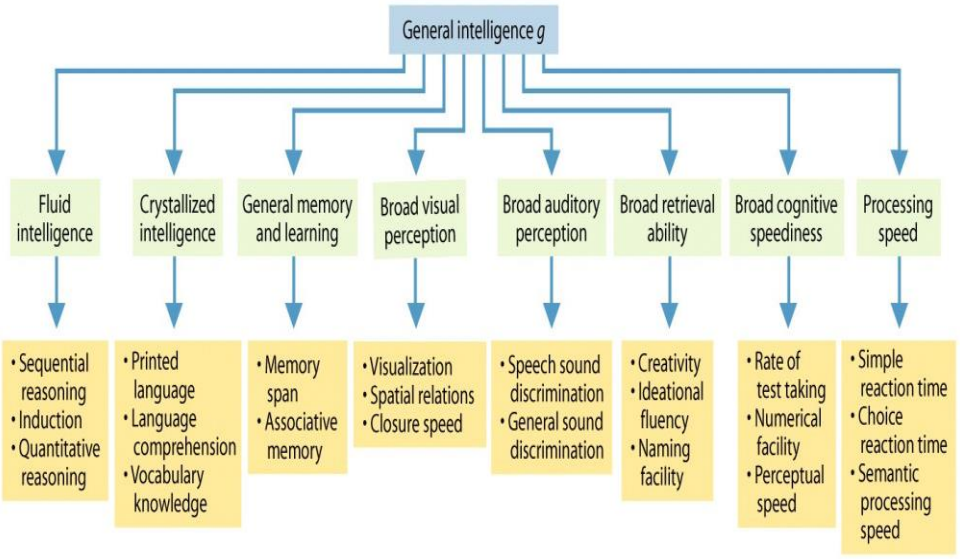
Educational Significance and Implications

1. Thurston's theory of intelligence was a major influence on later theories of multiple intelligences, such as those of Guilford, Gardner, and Sternberg.
2. if the individual wants to perform any particular activity, one or more of these factors or abilities are involved. Some of them are more important than others.

The Cattell-Horn-Carroll Theory of Cognitive Abilities(CHC)

Definition

A broad conception of intelligence that draws on Cattell and Horn's theory of fluid and crystallized intelligence and Carroll's three-stratum theory of cognitive abilities.



Description

The Catell-Horn-Carroll (CHC) theory of intelligence represents a combination of two previously proposed theories of cognitive abilities, the theory of fluid and crystallized intelligence (or Gf-Gc theory) associated with Catell and Horn, and John Carroll's three-stratum theory of cognitive abilities. Both Gf-Gc theory and Carroll's three-stratum theory are considered to be hierarchical theories of intelligence, in that they posit a broad cognitive ability with

multiple, more specialized abilities at lower levels of the hierarchy. Because of the significant overlap in the main components of the two theories, an integrated theory has been proposed that combines elements of both theories to provide an understanding of the broad range of abilities that are typically thought of as representing intelligence . CHC theory has been described as "the best validated model of human cognitive abilities ," and it is generally viewed as a significant advance in the understanding of intelligence due to its basis in empirical research on cognitive abilities.

The earliest versions of Gf-Gc theory posited that there are two main types of intelligence, fluid intelligence and crystallized intelligence. Fluid intelligence refers to the efficiency of cognitive functioning (e.g., memory and reasoning abilities), while crystallized intelligence refers to the stored learning that a person acquires over a lifetime. For many individuals, fluid intelligence peaks in the early 20's and 30's and then gradually declines as a result of the natural aging process. In contrast, crystallized intelligence continues to increase throughout much of the life span. Later versions of the theory have retained the Gf-Gc conceptualization, while also adding a number of second-order factors similar to those identified in Carroll's three-stratum theory.

John Carroll's theory of cognitive abilities was developed after Carroll conducted a review and reanalysis of over 460 studies on human cognitive abilities. Carroll developed what he called the three-stratum theory of cognitive abilities, which asserts that cognitive abilities can be described by examining different levels of specificity. At the most basic level (Stratum I), Carroll asserts that there are sixty-five narrow cognitive abilities, such as general sequential reasoning, memory span, speech sound

discrimination, and simple reaction time. These narrow stratum I abilities contribute to eight broad factors of cognitive abilities (Stratum II). These broad factors are fluid intelligence (G*f*), crystallized intelligence (G*c*), general memory and learning (G*y*), broad visual perception (G*v*), broad auditory perception (G*u*), broad retrieval ability (G*r*), broad cognitive speediness (G*s*), and decision/reaction time/speed (G*t*). Finally, each of these broad factors are conceptualized as contributing to an overall general intelligence (*g*).

The most direct application of CHC theory in the area of cognitive assessment is the Woodcock-Johnson III Test of Cognitive Abilities (WJ-III). The WJ-III was developed using CHC theory as a theoretical foundation . The test measures abilities at each of the three stratums, including stratum I (narrow cognitive abilities), stratum II (broad cognitive abilities) , and stratum III (general intellectual ability). The WJ-III has been praised as a significant advance in the measurement of cognitive abilities because of its theoretical base. Although the Wechsler and Stanford-Binet scales continue to dominate the intelligence testing field, the development of the WJ-III and other scales based on CHC theory has broadened the array of potential instruments for cognitive assessment. In addition, CHC theory has been somewhat influential as some of the more established instruments (WISC, SB) have been revised .

Most recently, The Cattell-Horn-Carroll (CHC) theory of cognitive abilities has been used for classifying intelligence and achievement batteries and neuropsychological tests to: (a) facilitate interpretation of cognitive performance; and (b) provide a foundation for organizing assessments for individuals suspected of having a learning disability , A brief overview of the evolution of CHC theory follows.

Fluid–Crystallized (*Gf-Gc*) Theory

The original *Gf-Gc* theory was a dichotomous conceptualization of human cognitive ability put forth by Raymond Cattell in the early 1940s. Cattell based his theory on the factor-analytic work of Thurstone conducted in the 1930s. Cattell believed that Fluid Intelligence (*Gf*) included inductive and deductive reasoning abilities that were influenced by biological and neurological factors as well as incidental learning through interaction with the environment. He postulated further that Crystallized Intelligence (*Gc*) consisted primarily of acquired knowledge abilities that reflected, to a large extent, the influences of acculturation (Cattell, 1957, 1971).

In 1965, John Horn expanded the dichotomous *Gf-Gc* model to include four additional abilities, including visual perception or processing (*Gv*), short-term memory (Short-term Acquisition and Retrieval—SAR or *Gsm*), long-term storage and retrieval (Tertiary Storage and Retrieval—TSR or *Glr*), and speed of processing (*Gs*). Later he added auditory processing ability (*Ga*) to the theoretical model and refined the definitions of *Gv*, *Gs*, and *Glr* (Horn, 1968; Horn & Stankov, 1982).

In the early 1990s, Horn added a factor representing an individual's quickness in reacting (reaction time) and making decisions (decision speed). The acronym or code for this factor is *Gt* (Horn, 1991). Finally, quantitative (*Gq*) and broad reading-writing (*Grw*) factors were added to the model based on the research of Horn (e.g., 1991) and Woodcock (1994), respectively. Based largely on the results of Horn's thinking and research, *Gf-Gc* theory expanded into an eight-factor model that became known as the Cattell-Horn *Gf-Gc* theory (Horn, 1991).

Carroll's Three-Stratum Theory

In his review of the extant factor-analytic research literature, Carroll differentiated factors or abilities into three strata that varied according to the "relative variety and diversity of variables" (Carroll, 1997, p. 124) included at each level. The various *G* abilities are the most prominent and recognized abilities of the model. They are classified as broad or stratum II abilities and include abilities such as *Gf* and *Gc*, the two original factors. According to Carroll (1993), *broad* abilities represent "basic constitutional and long standing characteristics of individuals that can govern or influence a great variety of behaviors in a given domain" and they vary in their emphasis on process, content, and manner of response (p. 634). Broad abilities, like *Gf* and *Gc*, subsume a large number of narrow or stratum I abilities of which approximately 70 have been identified (Carroll, 1993, 1997). *Narrow* abilities "represent greater specializations of abilities, often in quite specific ways that reflect the effects of experience and learning, or the adoption of particular strategies of performance" (Carroll, 1993, p. 634). The broadest or most general level of ability in the *Gf-Gc* model is represented by stratum III, located at the apex of

Carroll's (1993) hierarchy. This single cognitive ability, which subsumes both broad (stratum II) and narrow (stratum I) abilities, is interpreted as representing a general factor (i.e., *g*) that is involved in complex higher-order cognitive processes (Gustaffson & Undheim, 1996; Jensen, 1997; McGrew & Woodcock, 2001).

It is important to note that the abilities within each level of the hierarchical *Gf-Gc* model typically display nonzero positive intercorrelations (Carroll, 1993; Gustafsson & Undheim, 1996). For example, the different stratum I (narrow) abilities that define the various *Gf-Gc* domains are correlated positively and to varying degrees. These intercorrelations give rise to and allow for the estimation of the stratum II (broad) ability factors. Likewise, the positive nonzero correlations among the stratum II (broad) *Gf-Gc* abilities allow for the estimation of the stratum III (general) *g* factor. The positive factor intercorrelations within each level of the *Gf-Gc* hierarchy indicate that the different *Gf-Gc* abilities do not reflect completely independent (uncorrelated or orthogonal) traits. However, they can, as is evident from the vast body of literature that supports their existence, be reliably distinguished from one another and therefore represent unique, albeit related, abilities (see Keith & Reynolds, 2012).

Similarities and Differences Between the Cattell-Horn Model and the Carroll Model

Simplified versions of the Cattell-Horn and Carroll models of the structure of abilities (i.e., where the narrow abilities are omitted) are presented together in Figure 1, which

shows a number of important similarities and differences between the two models. In general, these models are similar in that they both include multiple broad abilities with similar descriptions (e.g., Gs) and similar classification of narrow abilities. However there are four major structural differences between the Cattell-Horn and Carroll models.

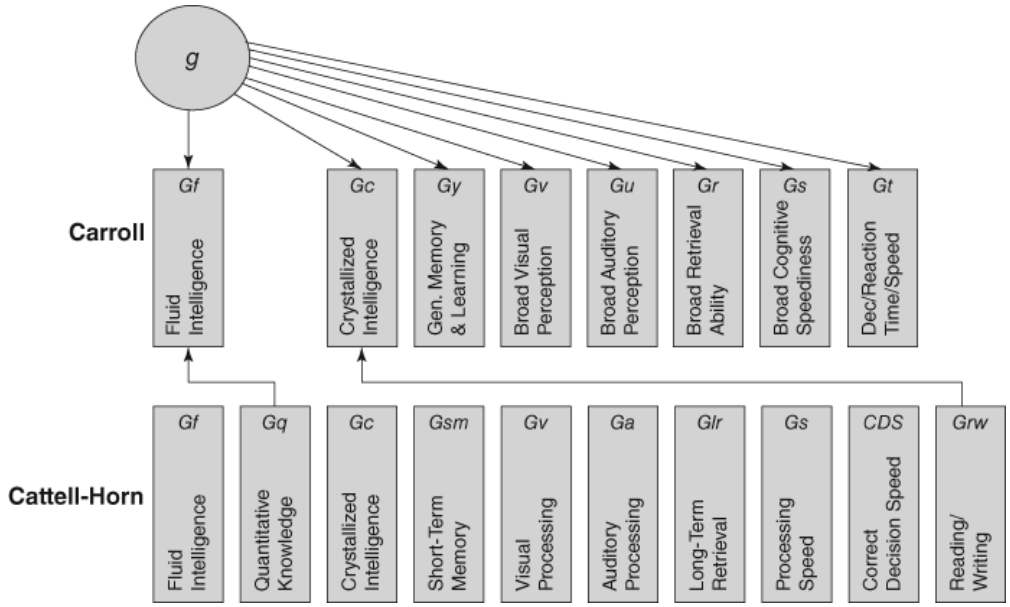


Figure1: Comparison of Cattell-Horn *Gf-Gc* theory and Carroll's Three-Stratum theory. *Source*: Flanagan & McGrew (1997).

First, Carroll's theory includes g (global or general ability) at stratum III and the Cattell-Horn theory does not, as these theorists disagreed over the existence of an overarching intellectual ability. This dispute is an ongoing debate in the field (see Schneider & McGrew, 2012 for a discussion on the existence of g).

Second, in the Cattell-Horn model, Gq is comprised of quantitative knowledge and quantitative reasoning; however,

Carroll classified quantitative reasoning as a narrow ability subsumed by Gf.

Third, the Cattell-Horn theory includes a distinct broad reading/writing (Grw) factor, whereas Carroll's theory includes reading and writing as narrow abilities subsumed by Gc.

Fourth, the Cattell-Horn and the Carroll models differ in their treatment of certain narrow memory abilities. Carroll combined both short-term memory and the narrow abilities of associative, meaningful, and free-recall memory with learning abilities under (Gy). Horn (1991) made a distinction between immediate apprehension (e.g., short-term memory span) and storage and retrieval abilities.

The First Generation of CHC Theory

Notwithstanding the important differences between the Cattell-Horn and the Carroll models, in order to realize the practical benefits of using theory to guide test selection, organization, and interpretation, it is necessary to define a single taxonomy—one that can be used to classify ability tests. A first effort to create a single taxonomy for this purpose was an integrated Cattell-Horn and Carroll model proposed by McGrew (1997). McGrew and Flanagan (1998) subsequently presented a slightly revised integrated model, which was further refined by Flanagan et al. (2000). The integrated model presented by McGrew and colleagues was accepted by both John Horn and John Carroll and thus became known as the Cattell-Horn-Carroll (CHC) theory, reflecting the order in which these theorists made their contributions. The original integration of the Cattell-Horn Gf-Gc theory and Carroll's three-stratum theory, or simply CHC

theory, is presented in Figure 2. This figure depicts the original structure of CHC theory and reflects the manner in which the Cattell-Horn and Carroll models have been integrated. In this figure, CHC theory includes 10 broad cognitive abilities, which are subsumed by over 70 narrow abilities.

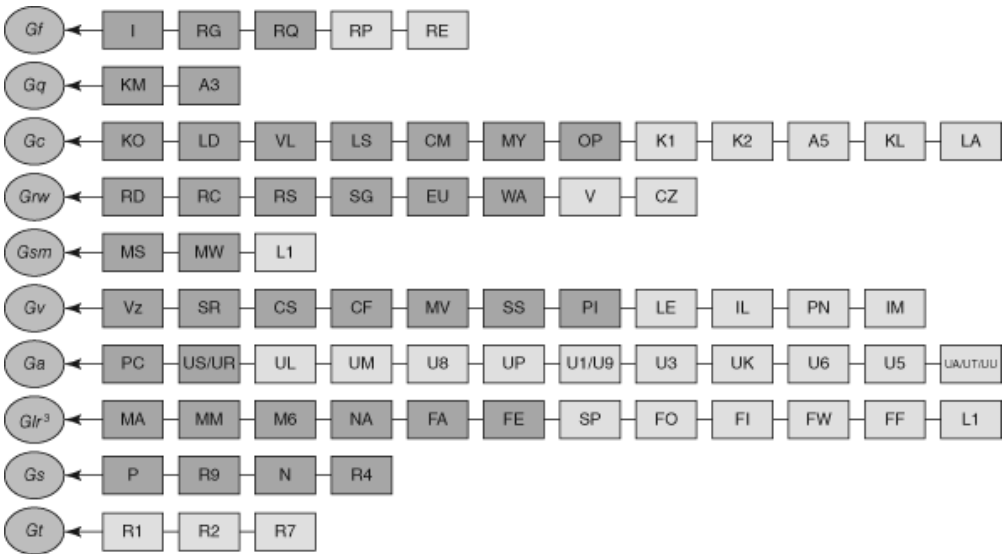


Figure 2:
Cattell-Horn-Carroll (CHC) theory. *Source*: Flanagan & McGrew (1997).

Latest Refinements to CHC Theory

A paramount feature of the CHC theory is that it is not static, but rather a dynamic model that is continuously reorganized and restructured based on current research. Recently, Schneider and McGrew (2012) conducted an extensive review on CHC theory by (1) analyzing the current theory and potential errors, (2) reviewing whether contemporary intellectual research validates or refutes the CHC model, (3) redefining constructs to be more meaningful

for clinicians, (4) adding, deleting, and restructuring the broad and narrow abilities within the model, and (5) highlighting which aspects of the model are more central to CHC theory. While a thorough explanation and description of the changes made to CHC theory is beyond the scope of this entry, the interested reader is referred to Schneider and McGrew (2012).

The current model of CHC theory is presented in Figure 3. In this model, CHC theory includes 16 broad cognitive abilities, which are subsumed by over 80 narrow abilities. The ovals represent broad abilities and rectangles represent narrow abilities. The darker rectangles represent those narrow abilities that are most consistently represented on tests of cognitive and academic abilities. Additionally, the overall g or general ability is omitted from this figure intentionally due to space limitations. The conceptual groupings of abilities (i.e., reasoning, acquired knowledge, memory and efficiency, sensory, motor, and speed and efficiency) were suggested by Schneider and McGrew and provide an integrated framework of both cognitive and neuropsychological perspectives (Flanagan et al., 2010). The CHC theory represented a culmination of more than 60 years of factor-analysis research in the psychometric tradition. However, in addition to structural evidence, there are other sources of validity evidence, some quite substantial, that support CHC theory. Prior to defining the broad and narrow abilities that comprise CHC theory, a brief overview of the validity evidence in support of this structure of cognitive abilities is presented.

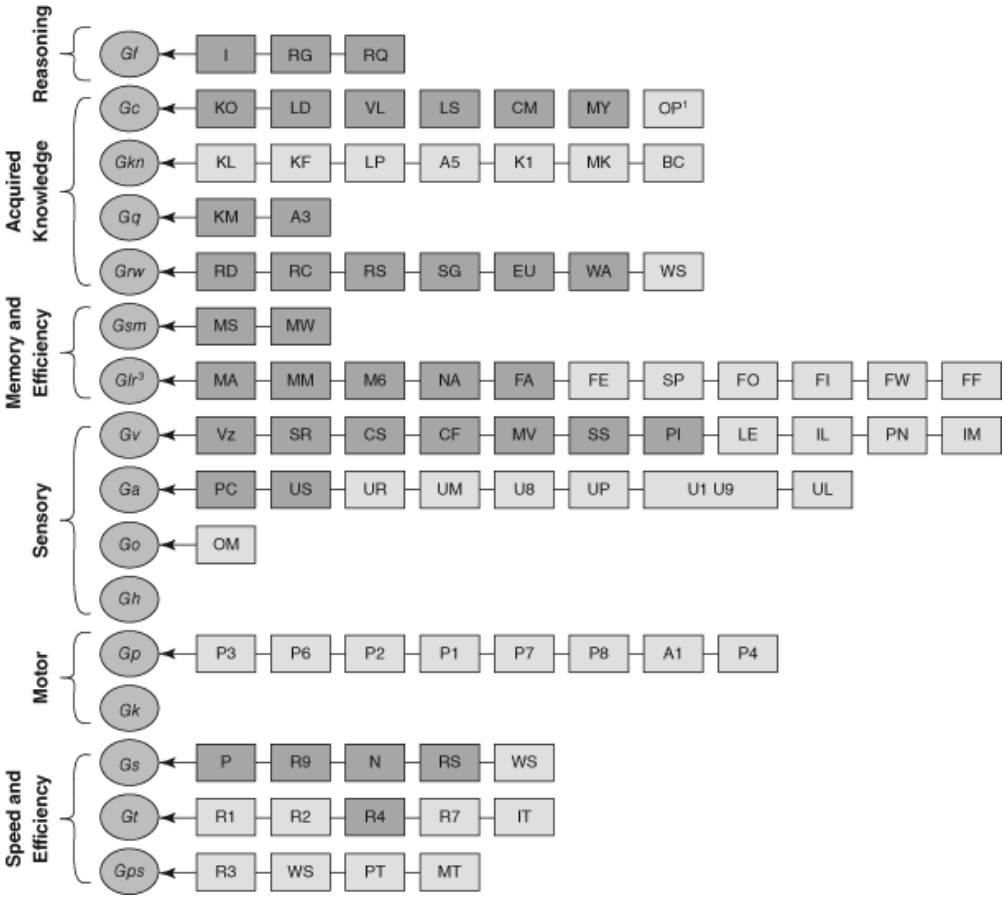


Figure3:
Current and expanded CHC theory of cognitive abilities. *Source*: Flanagan & McGrew (1997).

Fluid Intelligence (*Gf*)

Fluid intelligence refers to mental operations that an individual uses when faced with a relatively novel task that cannot be performed automatically. These mental operations may include forming and recognizing concepts, perceiving relationships among patterns, drawing inferences,

comprehending implications, problem solving, extrapolating, and reorganizing or transforming information. Gf can also be described as “deliberate but flexible control of attention to solve novel, ‘on-the-spot’ problems that cannot be performed by relying exclusively on previous learned habits, schemas, and scripts” (Schneider & McGrew, 2012, p. 111). Inductive and deductive reasoning are generally considered to be the hallmark narrow ability indicators of Gf. Although most practitioners would agree that this ability is typically not measured directly by individually administered achievement batteries, some tests of achievement clearly involve the use of specific Gf abilities. For example, many tests of reading comprehension require individuals to draw inferences from the text. Aside from general inductive and deductive reasoning abilities, Gf also subsumes more specific types of reasoning, most notably Quantitative Reasoning (RQ). Unlike the other narrow Gf abilities, RQ is more directly related to formal instruction and classroom-related experiences..

Crystallized Intelligence (*Gc*)

Crystallized intelligence refers to the breadth and depth of a person's acquired knowledge and skills that are valued by one's culture. This store of primarily verbal or language-based knowledge represents those abilities that have been developed largely through the “investment” of other abilities during educational and general life experiences (Horn & Blankson, 2005).

Gc includes both declarative (static) and procedural (dynamic) knowledge. Declarative knowledge includes factual information, comprehension, concepts, rules, and relationships, especially when the information is verbal in nature. Declarative knowledge is held in long-term memory

and is activated when related information is in working memory (Gsm). Procedural knowledge refers to the process of reasoning with previously learned procedures in order to transform knowledge. For example, a child's knowledge of his or her street address would reflect declarative knowledge, whereas a child's ability to find his or her way home from school would require procedural knowledge (Gagne, 1985).

General (Domain-Specific) Knowledge (*Gkn*)

It refers to the level of specialized knowledge that a person has in the field in which it has focused the most.

General (domain-specific) knowledge (Gkn) is the "depth, breadth, and mastery of specialized knowledge (knowledge not all members of a society are expected to have)" (Schneider & McGrew, 2012, p. 123).

This specialized knowledge is usually developed through an individual's work experience, hobbies, or passions. The Gkn broad ability is unique in that it is a domain that does not have a true G ability because the aggregates are of specific and distinct abilities. Furthermore, an individual should not be assessed in comparison with same age-peers in the general populations, but rather individuals who possess the same specialized knowledge base. For example, a sociologist's knowledge of human social behavior (i.e., Gkn narrow ability of sociology) should be compared only to other sociologists, not the general public.

Quantitative Knowledge (*Gq*)

Quantitative knowledge represents an individual's "depth and breadth of knowledge related to mathematics" (Schneider & McGrew, 2012, p. 127). The Gq store of acquired knowledge represents the ability to use quantitative information and manipulate numeric symbols. Gq abilities are typically measured by achievement tests. For example, most comprehensive tests of achievement include measures of math calculation, applied problems (or math problem solving), and general math knowledge. Although some intelligence batteries measure aspects of Gq (e.g., Arithmetic on the Wechsler Scales, Quantitative Reasoning on the SB5), they typically do not measure this ability comprehensively.

It is important to understand the difference between Gq and the Quantitative Reasoning (RQ) ability that is subsumed by Gf. On the whole, Gq represents an individual's store of acquired mathematical knowledge, including the ability to perform mathematical calculations (i.e., procedural knowledge). Quantitative Reasoning represents only the ability to reason inductively and deductively when solving quantitative problems. Gq is most evident when a task requires mathematical skills (e.g., addition, subtraction, multiplication, division) and general mathematical knowledge (e.g., knowing what the square-root symbol means). RQ, on the other hand, would be required to solve for a missing number in a number-series task (e.g., 3, 6, 9, ___), for example.

Reading/Writing Ability (*Grw*)

Reading/Writing ability is an acquired store of knowledge that includes basic reading, reading fluency, and writing skills required for the comprehension of written language and the expression of thought via writing. It

includes both basic abilities (e.g., reading decoding and fluency, spelling) and complex abilities (e.g., comprehending written discourse, writing a story). Like Gq, Grw is considered to be an "achievement" domain and, therefore, has been measured traditionally (and almost exclusively) by tests of academic achievement. In Carroll's (1993) three-stratum model, eight narrow reading and writing abilities are subsumed by Gc in addition to other abilities. In the CHC model, six of the eight narrow abilities define the broad Grw ability (verbal language comprehension [V] and cloze ability [CZ] were dropped because they were not distinct abilities), and an additional measure (writing speed [WS]) was included.

Short-Term Memory (*Gsm*)

Short-term memory is the ability to apprehend and hold information in immediate awareness and then use it within a few seconds. Gsm is a limited-capacity system, as most individuals can retain only seven "chunks" of information (plus or minus two chunks) in this system at one time. An example of Gsm is the ability to remember a telephone number long enough to dial it. Given the limited amount of information that can be held in short-term memory, information is typically retained for only a few seconds before it is lost. As most individuals have experienced, it is difficult to remember an unfamiliar telephone number for more than a few seconds unless one consciously uses a cognitive learning strategy (e.g., continually repeating or rehearsing the numbers) or other mnemonic device. When a new task requires an individual to use his or her Gsm abilities to store new information, the previous information held in short-term memory is either lost or must be stored in the

acquired stores of knowledge (i.e., Gc, Gq, Grw) through the use of Glr.

In the original CHC model, Gsm subsumes the narrow ability of working memory, which has received considerable attention in the cognitive psychology literature (see Kane, Bleckley, Conway, & Engle, 2001). However, in the recent revision of CHC theory, Schneider and McGrew renamed the narrow ability to Working Memory Capacity (MW), as it was more reflective of the tasks on cognitive and intelligence tests. Schneider and McGrew acknowledge that the current state of scientific literature on memory is immense, and therefore only relevant constructs are currently included in the CHC model. However, as research illuminates the correlations among different memory constructs and academic skills, it is likely that Gsm narrow abilities will continue to evolve.

Long-Term Storage and Retrieval (*Glr*)

Long-term storage and retrieval is the ability to store information in and fluently retrieve new or previously acquired information (e.g., concepts, ideas, items, names) from long-term memory. Glr abilities have been prominent in creativity research, where they have been referred to as idea production, ideational fluency, or associative fluency. It is important not to confuse Glr with Gc, Gq, and Grw, which represent to a large extent an individual's stores of acquired knowledge. Specifically, Gc, Gq, and Grw represent what is stored in long-term memory, whereas Glr is the efficiency by which this information is initially stored in and later retrieved from long-term memory.

Visual Processing (*Gv*)

Visual processing (Gv) is the ability to generate, perceive, analyze, synthesize, store, retrieve, manipulate, transform, and think with visual patterns and stimuli (Lohman, 1994), or more succinctly, "the ability to make use of simulated mental imagery to solve problems" (Schneider & McGrew, 2012, p. 129). These abilities are measured frequently by tasks that require the perception and manipulation of visual shapes and forms, usually of a figural or geometric nature (e.g., a standard block design task). An individual who can mentally reverse and rotate objects effectively, interpret how objects change as they move through space, perceive and manipulate spatial configurations, and maintain spatial orientation would be regarded as having a strength in Gv abilities. Gv abilities are also related significantly to higher-level mathematics achievement

Auditory Processing (*Ga*)

In the broadest sense, auditory processing is the "ability to detect and process meaningful nonverbal information in sound" (Schneider & McGrew, 2012, p. 131). Specifically, auditory processing is the ability to perceive, analyze, and synthesize patterns among auditory stimuli, and to discriminate subtle nuances in patterns of sound (e.g., complex musical structure) and speech when presented under distorted conditions. Although Ga abilities do not require the comprehension of language (Gc) per se, they are important in the development of language skills. Ga subsumes most of those abilities referred to as "phonological awareness/processing." Tests that measure these abilities (e.g., phonetic coding tests) are found typically on achievement batteries. In fact, the number of tests specifically designed to measure phonological processing has increased

significantly in recent years, presumably as a result of the consistent finding that phonological awareness/processing appears to be the core deficit in individuals with reading difficulties . However, as can be seen from the list of narrow abilities subsumed by Ga (Table C.9), this domain is very broad, extending far beyond phonetic coding ability.

Olfactory Abilities (*Go*)

Olfactory abilities refer to the "abilities to detect and process meaningful information in odors" (Schneider & McGrew, 2012, p. 132). This broad ability does not account for how sensitive one is to smell, but rather the cognitive processes an individual uses to interpret information from the olfactory system. While the current CHC theory lists only one Go narrow ability (Olfactory Memory [OM], research suggests that other narrow abilities (e.g., episodic odor memory, odor identification) may exist. Go was only recently added to the CHC model; therefore, more research is needed to identify additional narrow abilities or whether it is appropriately included in the model.

Tactile Abilities (*Gh*)

Tactile abilities are defined as "the abilities to detect and process meaningful information in haptic (touch) sensations" (Schneider & McGrew, 2012, p. 133). Similar to Go, Gh is not how sensitive one is to touch, but how one uses cognitive processes to interpret touch. Due to limited operational definitions of tactile abilities, there is currently little evidence supporting Gh narrow abilities. However, it is likely that further research will identify narrow abilities, such as tactile memory or knowledge of textures.

Psychomotor Abilities (*Gp*)

Psychomotor abilities are known as the "abilities to perform physical body motor movements (e.g., movement of fingers, hands, legs) with precision, coordination, or strength" (Schneider & McGrew, 2012, p. 134). Although Gp is not typically measured on cognitive and intelligence tests, psychomotor abilities are an important factor measured in neuropsychological assessments. For example, the Dean-Woodcock Neuropsychological Battery (Dean & Woodcock, 2003) includes several tasks designed to measure gross and fine motor skills (Flanagan et al., 2010). Psychomotor abilities are critical in understanding typical and atypical neuropsychological functioning, along with identifying any neurological or neuropsychological disorders.

Kinesthetic Abilities (*Gk*)

Kinesthetic abilities are known as the "abilities to detect and process meaningful information in proprioceptive sensations" (Schneider & McGrew, 2012, p. 133). Proprioception refers to one's awareness of body position and movement (Westen, 2002). Although there is currently a limited understanding of Gk narrow abilities, we can infer they may include abilities such as a yogi being able to feel the correct body position in a pose, or a swimmer being able to demonstrate an adjustment in arm position that improves technique.

Processing Speed (*Gs*)

Processing speed or mental quickness is often mentioned when talking about intelligent behavior (Nettelbeck, 1994). Processing speed is the "ability to perform simple, repetitive

cognitive tasks quickly and fluently" (Schneider & McGrew, 2012, p. 119). These cognitive tasks often require maintained focused attention and concentration; therefore, "attentive speediness" encapsulates the essence of Gs. Gs is measured typically by fixed-interval timed tasks that require little in the way of complex thinking or mental processing (e.g., the Wechsler Animal Pegs, Symbol Search, Cancellation, and Digit Symbol/Coding tests).

Recent interest in information-processing models of cognitive functioning has resulted in a renewed focus on Gs (Kail, 1991; Lohman, 1989, McGrew, 2005). A central construct in information-processing models is the idea of limited processing resources (e.g., the limited capacities of short-term and working memory): "Many cognitive activities require a person's deliberate efforts and people are limited in the amount of effort they can allocate. In the face of limited processing resources, the speed of processing is critical because it determines in part how rapidly limited resources can be reallocated to other cognitive tasks" (Kail, 1991, p. 492). Woodcock (1993) likens Gs to a valve in a water pipe. The rate at which water flows in the pipe (i.e., Gs) increases when the valve is opened wide and decreases when the valve is partially closed.

Decision Speed/Reaction Time (*Gt*)

In addition to *Gs*, both Carroll and Horn included a second broad speed ability in their respective models of the structure of abilities. Processing Speed or Decision Speed/Reaction Time (*Gt*), as proposed by Carroll, subsumes narrow abilities that reflect an individual's quickness in reacting (reaction time) and making decisions (decision speed). *Gt* is also considered as the "speed of making very simple decisions or

judgments when items are presented one at a time" (Schneider & McGrew, 2012, p. 120). Correct Decision Speed (CDS), proposed by Horn as a second speed ability (*Gs* being the first), is typically measured by recording the time an individual requires to provide an answer to problems on a variety of tests (e.g., letter series, classifications, vocabulary; Horn, 1988, 1991). Because Correct Decision Speed appeared to be a much narrower ability than *Gt*, it is subsumed by *Gt* in CHC theory.

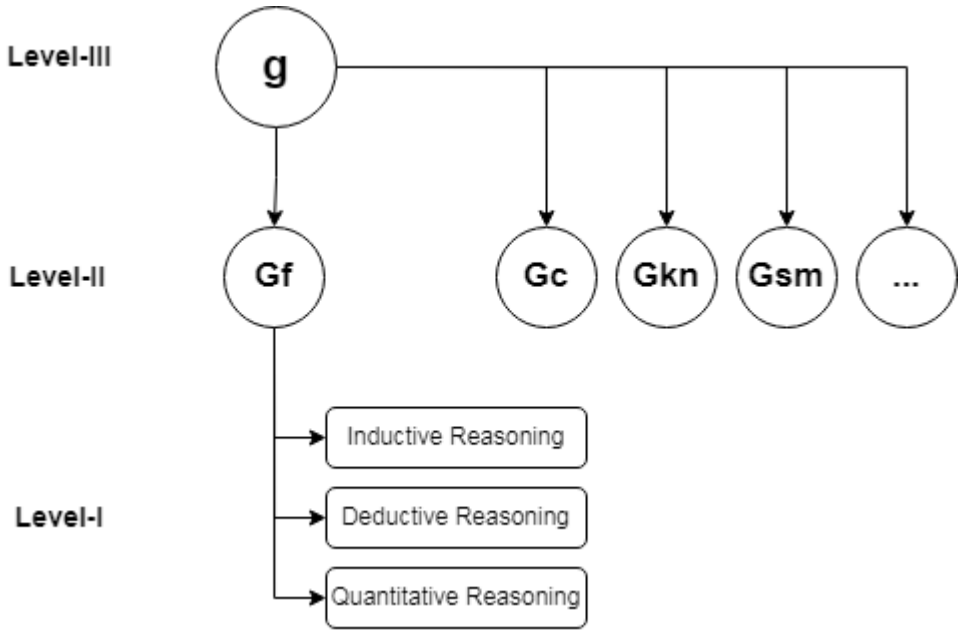
It is important not to confuse *Gt* with *Gs*. *Gt* abilities reflect the immediacy with which an individual can react to stimuli or a task (typically measured in seconds or parts of seconds), whereas *Gs* abilities reflect the ability to work quickly over a longer period of time (typically measured in intervals of 2 to 3 minutes). Being asked to read a passage (on a self-paced scrolling video screen) as quickly as possible and, in the process, touch the word *the* with a stylus pen each time it appears on the screen, is an example of *Gs*. The individual's *Gs* score would reflect the number of correct responses (taking into account errors of omission and commission). In contrast, *Gt* may be measured by requiring a person to read the same text at his or her normal rate of reading and press the space bar as quickly as possible whenever a light is flashed on the screen. In this latter paradigm, the individual's score is based on the average response latency or the time interval between the onset of the stimulus and the individual's response.

Psychomotor Speed (*Gps*)

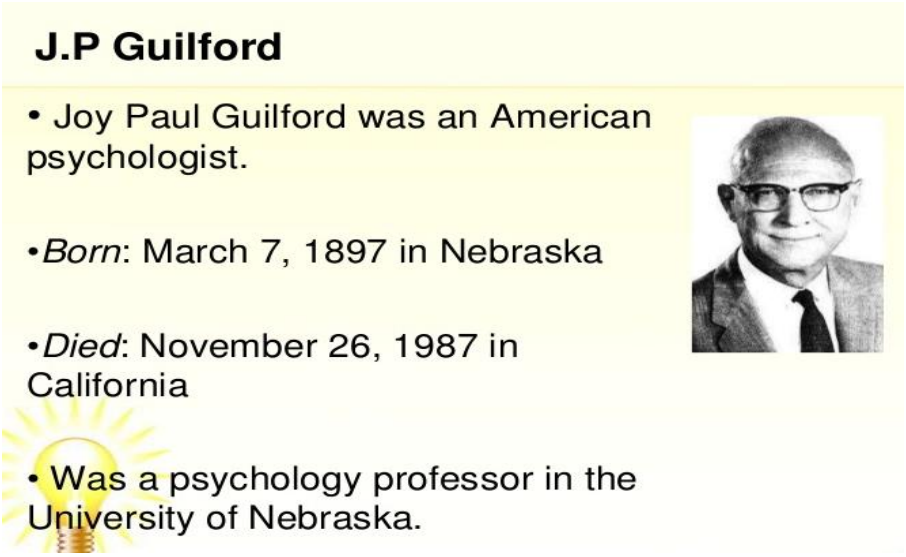
Psychomotor speed is the "speed and fluidity with which physical body movements can be made" (Schneider & McGrew, 2012, p. 121). Psychomotor speed tasks are rarely

measured on assessment batteries, with the exception of finger-tapping tasks in some neuropsychological tests. There are currently four narrow abilities of Gps, which are described in Table C.15.

A great way to understand the hierarchical structure of intelligence abilities is to see them graphically. Below you can visualize in english the structure showing fluid intelligence and its narrow abilities at level-I plus other level-II broad abilities as an example:



Structure of Intellect Model: SI Model
By
P. J. Guilford



In 1955, J. P. Guilford – an early proponent of the idea that intelligence is not a unitary concept – first presented his structure of intellect model (Figure 9), which he continued to revise through the years based on empirical psychometric research.

In that model, individual's brain structures are able to process different types of information in different ways. intelligence depends upon how a person uniquely processes information. for example, Some students are good at breaking down physical problems into units…. While others are good at recognizing symbols with the help of their memory.

Structure of Intellect originated in Guilford's multiple intelligence theory. it is used as an assessment tool for students. it can determined learning disabilities as well as enrichment for gifted students.

A person's intelligence can be categorized by 180 different components in three different independent dimensions or categories:

1- contents: they are areas on which operations are applied .Example: Materials presented to the examinees. there are five kinds of contents (visual, auditory, symbolic, semantic, behavioral)
2- Operations: they are general intellectual processes required by a test (exam). There are 6 kinds of operations (cognition, memory recording, memory retention, divergent production, convergent production, evaluation).
3- products: they are the result of applying operations on contents (final outcome after the application of our intellectual abilities). there are six kinds of products (units, classes, relations, systems, transformations, implications).

Since each of these dimensions is independent, there are theoretically 180 different components of intelligence.
each ability stands for a particular operation in a particular content area and results in a specific product, such as comprehension of visual units or evaluation of semantic implications.

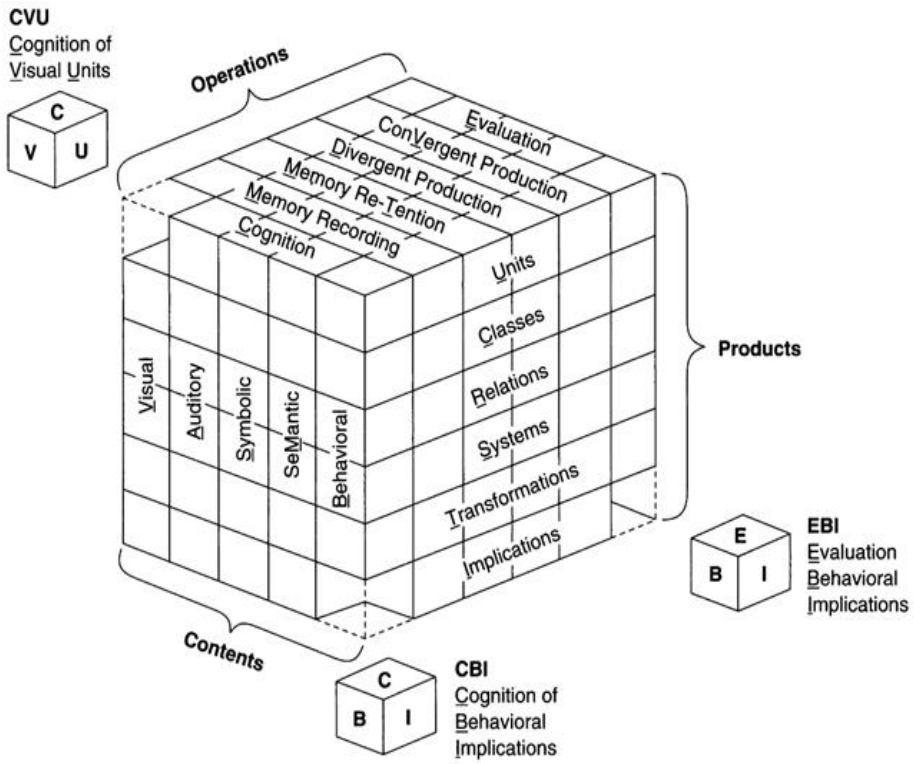


Figure 9. Guilford's structure of intellect model.

Contents:

1- **Visual contents**: information presented to the eyes.
2- **Auditory contents**: information presented to the ears.
3- **Symbolic contents**: information perceived as a symbols or signs that stand for something, e.g., Arabic numerals, the letters of an alphabet, or scientific notations
4- **Semantic contents**: Words/ sentences – verbal meanings, ideas, oral/ written or in one's mind words.
5- **Behavioral Contents**: information regarding people's behavior and actions (e.g., mental state and behavior of other people).

Operations

1- **Cognition**: the ability to understand, comprehend, discover and become aware of information.
2- **Memory recording**: the ability to store / encode information.
3- **Memory retention**: the ability to recall information.
4- **Convergent Production**: ability to arrive at one single solution to a problem (problem solving).
5- **Divergent Production**: the ability to general multiple solutions to a problem (creativity).
6- **Evaluation: the** ability to judge the information critically whether its correct or incorrect.

Products

1- **Units:** Single items of knowledge, e.g. one number, one word, …etc. is a single symbol, figure, word, object, or idea. Example: each real number. symbolic units such as words. visual units such as shapes. behavioral units such as facial expressions.

2- **Classes:** Organizing units into groups based on shared attributes. sets of units sharing common information e.g., two words or sentences combined. Sort units into the right groups. The class is sets of items grouped by virtue of their common properties Example: set of real numbers, Even numbers, Acids / equation solution group, Super ordinate concepts (children = girls + boys).

3- **Relations:** Linking units either as opposites, associates, sequences or analogues. connection between two items such as e.g., mathematical proving of a problem. sense the relationships between pairs of units.

connections and linkages between concepts. connections between items of information Example: equality and inequality are relation in the set of real numbers.

4- **Systems:** Multiple relation between units to create a network/ structures. three or more items forming a whole, such as a full song, an equation. System consists of the relationships among more than two units. an ordering and the classification of relations. It is a composition of units, classes, and relationship into a larger and more meaningful structure. Example: the set of real numbers together with the operations of addition, subtraction, multiplication, and division and the algebraic properties of these operations. others Examples: Visual system: plate/map. Symbolic system: mathematical equations. Semantic system: the story. Behavioral system: the social situation, including trends, social perceptions, and goals.

Transformations: Changes, perspectives, mutations to knowledge. changes in an item of information, such as correction of spellings/ correction of solution (update, modify solution/ transforming previously thought of idea into a new idea). changes in information, such as rotation of visual figures . altering or restructuring intellectual contents. The transformation ability is the process of modifying, reinterpreting, and restructuring existing information into new information. The transformation ability is usually thought to be characteristic of creative people. Example: functions defined on the real number system.

Visual transformation: moving an element (rotation/reflection). Symbolic transformation: solving algebraic mathematical equations. Transformation in semantic content: a change that occurs in the meaning or connotation. Transformation in behavioral content: the change that occurs in behavior, mood, or attitudes.

5- **Implementations:** deriving a meaning, drawing a conclusion, or predicting. inferring from pieces of information. Implementation is a prediction about the consequences of interactions among units, classes, relations, systems, and transformations. Example: each theorem about function on the real numbers.

Principles

- Reasoning and problem-solving skills (convergent and divergent operations) can be subdivided into 30 distinct abilities (6 products x 5 contents).
- Memory operations can be subdivided into 30 different skills (6 products x 5 contents).
- Decision-making skills (evaluation operations) can be subdivided into 30 distinct abilities (6 products x 5 contents).
- Language-related skills (cognitive operations) can be subdivided into 30 distinct abilities (6 products x 5 contents).

- Implications for education

- the structure of intellect's philosophy is that intelligence is not fixed.
- intelligence can be learnt.
- need to consider all students are different.

Example:

The following example illustrates closely related abilities that differ in terms of operation, content, and product.

- Evaluation of semantic units (EMU) is measured by the ideational fluency test in which individuals are asked to make judgments about concepts. For example: "Which of the following objects best satisfies the criteria, hard and round: an iron, a button, a tennis ball or a light bulb?
- Divergent production of semantic units (DMU) would require the person to list all items they can think of that are round and hard in a given time period.
- Divergent production of symbolic units (DSU) involves a different content category than DMU, namely words (e.g., "List all words that end in 'tion').
- Divergent production of semantic relations (DMR) would involve the generation of ideas based upon relationships. An example test item for this ability would be providing the missing word for the sentence: "The fog is as ____ as a sponge" (e.g., heavy, damp, full).

Questions:

- **a science teacher has to treat a student with learning disabilities. What operations, contents and products will be involved in this intellectual process?**

- **Identify the ability that best describe the following performance:**
  - **the ability to perceive changes in the expressions of an individual (student).**
- **Identify the ability that best describe the following performance:**
  - **the ability to judge changes in emotions of an individual (student).**
- **identify the element of production in the following items:**
  - **List as many possible uses of fungi / levers?**

Multiple Intelligences Theory : MI Theory

The Multiple Intelligences Theory throws away the idea that intelligence is one sort of general ability and argues that there are actually eight types of intelligence. One is not more important than the other, but some may help people succeed at different things.

For example, a person with high musical intelligence and low visual-spatial intelligence may succeed in music class but may struggle in art class.

Howard Gardner's Theory of Multiple Intelligence

Howard Gardner(1983) defined "The ability to solve problems or to create products that are valued within one or more cultural settings." *Intelligence Reframed (1999)* "A biopsychological 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."

Howard Gardner of Harvard University first came up with the theory of multiple intelligences in 1983. Gardner argues that there are eight types of intelligence, far more than the standard I.Q. test can account for.

He goes on to say that these multiple intelligences "challenge an educational system that assumes that everyone can learn the same materials in the same way

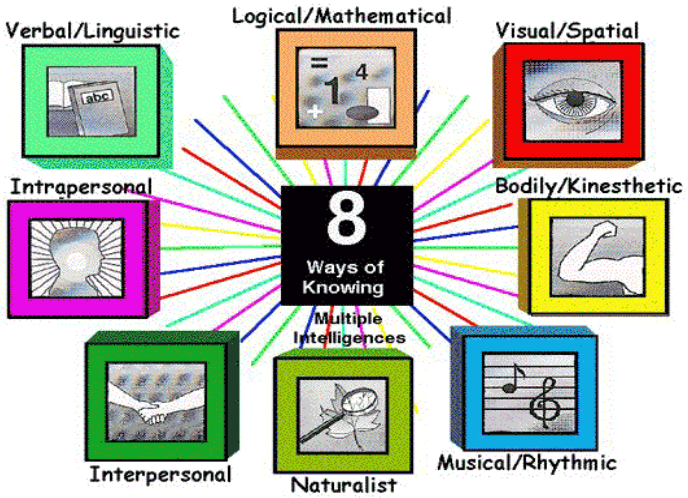
and that a uniform, universal measure suffices to test student learning.”

Gardner argues that schools and teachers should teach in a way that supports all types of intelligence, not just the traditional ones such as linguistic and logical intelligence.

Reasoning Behind Gardner’s Theory

- “Individuals should be encouraged to use their preferred intelligences in learning.”
- “Instructional activities should appeal to different forms of intelligence.”
- “Assessment of learning should measure multiple forms of intelligence.”

At least eight ways that humans perceive and understand the world, Theorized by Howard Gardner in 1983



1- Linguistic Intelligence

Linguistic intelligence, also called verbal-linguistic intelligence, is about knowledge of language use, production, and possibilities.

Those with this type of intelligence have the ability to use language to express themselves and assign meaning by way of poetry, humor, stories, and metaphors. Listen and respond to the spoken word, Enjoys reading, writing, and discussing ,Remember what has been said, Remember what has been read, and Speaks and writes effectively. It is common for comedians, public speakers, and writers to be high in linguistic intelligence.

Teaching for Linguistic Intelligence:

Use the following activities and techniques for students and groups with high linguistic intelligence:

- Use creative writing activities such as poetry or scriptwriting
- Set up class debates
- Allow for formal speaking opportunities
- Use humor, such as joke writing or telling
- Make sure there are plenty of reading opportunities

Learning with Linguistic Intelligence:

Learn your best by writing, practicing speeches, creating jokes, journaling, and reading.

2- Logical-Mathematical Intelligence

Logical-mathematical intelligence is commonly thought of as “scientific thinking,” or the ability to reason, work with abstract symbols, recognize patterns, and see connections between separate pieces of information. Likes math and using technology to solve complex problems. Uses abstract symbols to represent concrete objects and concepts . Uses an Inductive and deductive thinking and reasoning abilities, logic as well as the use of numbers and abstract pattern recognition.

It makes it possible to go through the scientific process of calculating, quantifying, hypothesizing, and concluding.

This type of intelligence is high in scientists, mathematicians, computer programmers, lawyers, and accountants.

Teaching for Logical-Mathematical Intelligence:

Use the following activities and techniques for students and groups with high logical-mathematical intelligence:

- Provide opportunities for problem-solving
- Involve calculations
- Create activities that involve deciphering a code
- Use pattern or logic games
- Organize new information in an outline format

Learning with Logical-Mathematical Intelligence:

Learn your best by creating information outlines with points, and making patterns of the information.

3- Visual-Spatial Intelligence

Visual-spatial intelligence is all about the visual arts, graphics, and architecture. This type of intelligence allows people to visualize objects from different perspectives and in different ways, use objects within space, form mental images, and think in three-dimensions. People high in visual-spatial intelligence include painters, architects, graphic designers, pilots, and sailors.

Teaching for Visual-Spatial Intelligence:

Use the following activities and techniques for students and groups with high visual-spatial intelligence:

- Use mind mapping techniques
- Use guided visualizations or verbal imagery
- Provide opportunities for artistic expression using a variety of mediums (paint, clay, etc.)
- Allow for make-believe or fantasy
- Create collages for visual representations

Learning with Visual-Spatial Intelligence:

Learn your best by creating something visual using space such as a collage, art piece, or written map of the information.

4- Bodily-Kinesthetic Intelligence

Bodily-kinesthetic intelligence is the ability to use the body to express emotion, play games, or create new products. It is commonly referred to as “learning by doing.” This type of intelligence enables people to manipulate objects and the body. manipulate what is to be learned, Develops coordination and a sense of timing, Learns best by direct involvement and participation, Remembers most clearly what was done, rather than what was said or observed.

High bodily-kinesthetic intelligence is common in dancers, athletes, surgeons and artisans.

Teaching for Bodily-Kinesthetic Intelligence:

Use the following activities and techniques for students and groups with high bodily-kinesthetic intelligence:

- Use body sculpture
- Use of role-playing, miming, or charade games
- Allow for physical exercise, dance, or martial arts
- Create opportunities for dramatic arts such as skits
- Use human graphs

Learning with Bodily-Kinesthetic Intelligence:

To learn at your best, try creating a movement routine or role-play to learn a concept or remember information.

5- Musical Intelligence

Musical intelligence is all about music. Individuals with high musical intelligence have a greater knowledge

of and sensitivity to tone, rhythm, pitch, and melody. But this type of intelligence isn't just about music — it's also about sensitivity to the human voice, audio patterns, and sounds in the environment, and organizes such sounds into meaningful patterns

Composers, musicians, conductors, and sound directors all have high musical intelligence.

Teaching for Musical Intelligence:

Use the following activities and techniques for students and groups with high musical intelligence:

- Use instruments and instrument sounds
- Use environmental sounds to illustrate a concept
- Allow for musical composition and performance
- Allow students to create songs about a topic

Learning with Musical Intelligence:

To learn best with your musical intelligence, try making a song with content you need to know.

6- Interpersonal Intelligence

Interpersonal intelligence is all about working with others and communicating effectively with others both verbally and nonverbally. It involves the ability to notice distinctions in others' moods, temperaments, intentions, and motivations, the ability to Sensitive to leadership opportunities, others' feelings; "street smart" and the ability to Forms and maintains social relationships.

Perceives the feelings, thoughts, motivations, behaviors, and lifestyles of others

High interpersonal intelligence is often found in teachers, counselors, politicians, and religious leaders.

Teaching for Interpersonal Intelligence:

Use the following activities and techniques for students and groups with high interpersonal intelligence:

- Teach collaborative skills
- Provide plenty of group work opportunities
- Use person-person communication
- Use empathy

Learning with Interpersonal Intelligence:

To learn best with high interpersonal intelligence, try doing most of your work in a group or with another person. Try to put yourself in the shoes of people or situations you are learning about.

7- Intrapersonal Intelligence

Intrapersonal intelligence involves knowledge of the self in ways such as feelings, a range of emotional responses, and intuition about spirituality. This type of intelligence allows people to be conscious of the unconscious, to discern higher patterns of connection between things in our world, aware of his range of emotions.

motivated to identify and follow goals, Works independently. Establishes and lives by an ethical value system, Strives for self-actualization.

Psychologists, philosophers, and theologists have high intrapersonal intelligence.

Teaching for Intrapersonal Intelligence:

Use the following activities and techniques for students and groups with high intrapersonal intelligence:

- Practice meditation
- Allow for plenty of self-reflection
- Use mindfulness
- Practice reaching altered states of consciousness

Learning with Intrapersonal Intelligence:

To learn best with intrapersonal intelligence, try using mindful walks, meditation, and metacognition.

8- Naturalist Intelligence

Naturalist intelligence is about discerning, comprehending, and appreciating plants, animals, the atmosphere, and the earth. It involves knowing how to care for animals, live off the land, classify species, and understand systems in nature.

Some of the characteristics of those students with naturalist intelligence include their:

- physically/emotionally adverse to pollution
- intense interest in learning about nature
- powers of observation in nature
- awareness of changes in weather

High naturalist intelligence is seen in farmers, zookeepers, botanists, nature guides, veterinarians, cooks, and landscapers/gardeners.

Teaching for Naturalist Intelligence:

Use the following activities and techniques for students and groups with high naturalist intelligence:

- Practice conservation
- Have a classroom plant or animals to care of
- Observe nature, go on nature walks
- Use species classification
- Provide hands-on labs of natural materials

Learning with Naturalist Intelligence:

To learn at your best, do your learning outdoors. Work with natural materials or animals as much as possible to work through concepts.

Gardner notes that

> "such persons with a high degree of naturalist intelligence are keenly aware of how to distinguish

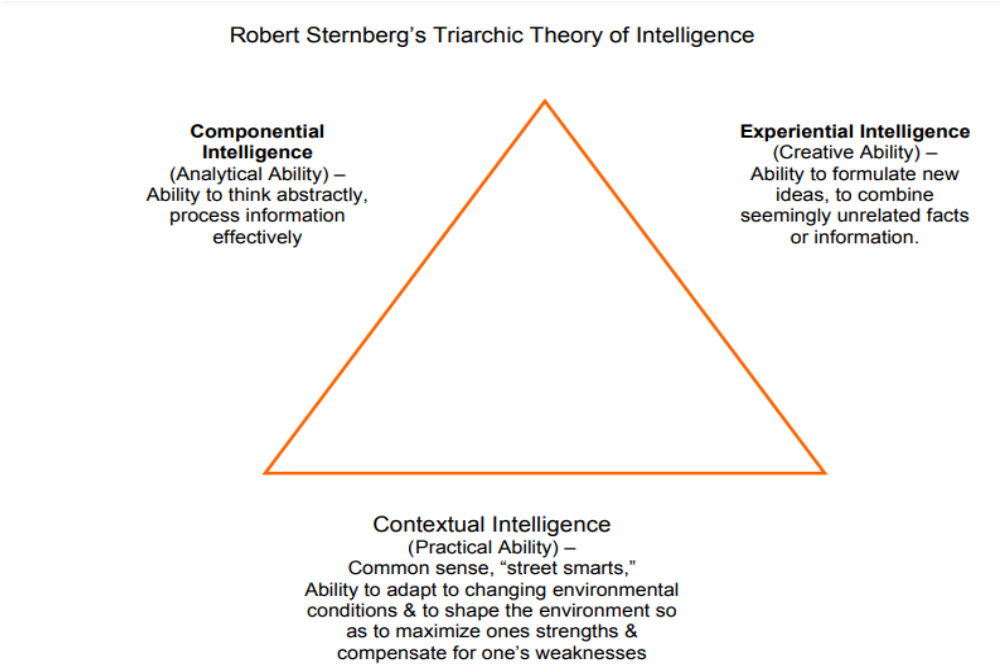
the diverse plants, animals, mountains, or cloud configurations in their ecological niche."

According to Gardner, "Successful education does not require covering everything 'from Plato to NATO.' In fact, the greatest enemy of understanding is coverage. If we try to cover everything, by the end of the day people will have learned very little and will have understood nothing. As a teacher, ask yourself, 'If I had one hour (per semester) to teach students, what would I teach them?'"

The Impact on Schools

- We teach all children the way we have met the needs of the gifted in the past
- Move beyond traditional methods; incorporate the other six intelligences in teaching, assessing and planning
- Teachers are better able to create more "inclusive, affective and effective instruction" (Owen

Successful Intelligence theory



Successful Intelligence: Use Your Smarts to Solve Problems in SchooL. Successful Intelligence theory asserts that a person's overall intelligence comprises three distinct elements -- a combination of analytical, creative, and practical thinking skills.

You may know your learning style and how intelligent you are, but how do you use your intelligence to solve problems? Successful Intelligence theory asserts that a person's overall intelligence comprises three distinct elements -- that when you are trying to solve a problem you use a combination of analytical, creative, and practical thinking skills.

In his book, Successful Intelligence (Simon & Schuster), Robert Sternberg refutes the idea of any one definition of intelligence. Instead, he suggests that successful intelligence determines one's ability to cope in career, in life -- and in school. Successfully intelligent people capitalize on their strengths and recognize and compensate for their weaknesses; self-motivating and flexible in their work style, they create their own opportunities, actively seek out role models, recognize and accurately define problems, and know when to persevere.

Successful intelligence is the kind of intelligence you need to succeed both in school and in the real world. It is the translation of underlying skills and abilities into routines that lead to highly competent, everyday performances -- on the job, in personal relationships, and in the classroom.

More specifically, Sternberg describes successful intelligence as the ability to balance analytical, practical, and creative intelligence and use these intelligences effectively. And the best news from his more recent work is the affirmation that people can actually perform exercises to improve their three types of thinking.

- Analytical intelligence involves the conscious direction of our mental processes to find a thoughtful solution to a problem. It is the ability to overcome obstacles to find a solution. Being analytically intelligent is having the ability to solve problems effectively.

- Creative intelligence is the ability to come up with new ideas. With creative intelligence, a person can generate innovative solutions to solve problems.

- Practical intelligence is common sense and deals mostly with social situations. Some might refer to this aspect of intelligence as street-smarts.

To find out your level of successful intelligence, take this assessment on our sister site, Quintessential Careers: What's Your Degree of Analytical, Creative, and Practical Thinking?A Quintessential Careers Quiz.

How did you do? Which skills do you need to improve? Following are suggestions for improving your thinking skills in each area when solving problems. These suggestions are excellent for working through obstacles you come across in class projects. After each set of suggestions, see how a student named Megan Cahoon, in an assignment she published on the Internet, described academic experiences she'd had relating to successful intelligence.

Improving Analytical Thinking Skills

- ✓ Seek out more (complete) information about the situation/decision.
- ✓ Separate the information you do have into fact and opinions.
- ✓ Evaluate and decide on the importance of each piece of information.
- ✓ Break down larger concepts into smaller, easier to manage pieces.
- ✓ Dedicate time to gather, read, and evaluate information.

Megan Cahoon noted that she encountered analytical thinking skills when she attempted to publish a personal web page, but it didn't work. She defined her problem and decided the best course would be to start over. She recreated the page step by step and at each juncture tested whether it would actually work when published on the Internet.

Improving Creative Thinking Skills

- ✓ Take risks by pushing yourself out of your comfort zone when seeking understanding.
- ✓ Seek out examples of the creative solutions of others to similar situations.
- ✓ Examine the situation you face from multiple perspectives.
- ✓ Go beyond obvious and conventional solutions.

- ✓ Free yourself to brainstorm (develop) multiple solutions to situation.

Megan Cahoon described encountering her creative thinking skills when she made a paper collage in a class. She detailed the color choices she made and very simple materials she used in making a black cat the centerpiece of her collage.

Improving Practical Thinking Skills

- ✓ Try to observe how others work and make decisions.
- ✓ Examine how others have successfully accomplished things.
- ✓ Look for patterns in past experience to prepare for future decisions/situations.
- ✓ Read and review common-sense tips for everyday situations.
- ✓ Apply what you have learned from the past to present day.

Types of Students in a Classroom: Behavior Types

Teachers face many different challenges in the classroom. Disruptive and disrespectful behavior however cannot be tolerated. Here are some of the types of challenging behavior that teachers may encounter in the classroom.

Each student possesses a unique character and way of engaging with the world, which inevitably translates into their classroom behaviors. As educators, comprehending the various student personas can make instruction more efficient, productive, and rewarding. There's a rich tapestry of student attitudes and behaviors one might encounter, and the strategies used to engage them should be equally diverse. This discussion will delve into five stereotypical student personas often found in classrooms, offering evidence-based approaches for dealing with each one. This categorization is centered on behavioral tendencies rather than factors like learning style, age, etc.

1) The Chatterbox

Talking in class when a lesson is being taught is disrespectful to both the teacher and the other students. It is important for students to understand that this behavior is unacceptable and rude. There are a number of ways to stop the chattering but isolating the student or ordering them to stop will only cause resentment. Rather than using negative forms of correction, simply stop speaking and wait for the talking to cease. Once this has happened, direct a thank you and a smile towards the students who were interrupting.

2) The Alpha

Teachers may often encounter a power struggle with certain students who refuse to do any work or cooperate in any way. Don't be dragged into this power play. Give the student a clear choice of either doing the work or not doing the work and facing the consequences. This could include missing out on free time or fun activities. This way, you are putting the responsibility on the student to make the right choice. When they do start to do their work, make sure to acknowledge their good behavior with smiles and encouragement.

3) The Argumentative

Being contradicted by a student is another form of power play which must be nipped in the bud immediately. Try not to be sucked into an argument while also not completely disregarding the student's opinion. Defiant students may feel the need to assert themselves even more when they are presented with opposition. Instead, calmly explain that this is not the right time to have that discussion and move on. If the

student persists, suggest an after class discussion of the problem. Remember to encourage curiosity and questioning in your students while still remaining in control of the class.

4) The Brooder

Having a moody or brooding student is a distraction for the teacher also. It is important to have a discussion with the student as soon as you notice this behavior, especially if it is out of character or a sudden change. Have a descrete discussion with the student after class to try and get to the root cause of the problem. There may be issues at home, bullying or other problems going on in the student's life that may be getting them down. It is your call whether or not the behavior is worrying enough to notify the parents.

5) The Clinger

A student who constantly calls for your assistance may be doing so out of the need for attention or may genuinely not be able to understand the task at hand. It is your job to properly evaluate the situation and assess if there may be a learning disability involved. If you do feel that it is a cry out for attention then you will have to make the student more dependent on their own. When they ask you to explain a task for the second time, tell them that they can ask the student beside them. Encourage them to attempt the work before calling for your assistance and give your note of approval when the work is done properly.

6). Backbenchers

The term ‘backbencher’ typically refers to students who prefer to sit in the back rows of the classroom, often drawing unwarranted suspicion from teachers. These students might be seen sleeping, listening to music, watching videos, or engaging in idle chatter during class time. However, it is crucial not to hastily label them as “uninterested” or “unruly”.

To better engage with backbenchers, it is suggested that teachers adopt a dynamic classroom presence, circulating the room during discussions to ensure that all students are given equal attention (Hill & Flynn, 2006). This strategy, termed ‘proximity control,’ has been empirically shown to increase on-task behavior while decreasing disruptive actions (Gunter, Hummel, & Conroy, 1998).

7). Overachievers

Overachievers are students who exhibit extraordinary enthusiasm in every task. They’re the ones who actively participate in every discussion, overperform in activities, and often join numerous clubs. However, their high-profile presence can sometimes overshadow others, leading to a decrease in class-wide participation.

Academic experts like Hany (1993) suggest that educators should approach overachievers through direct communication. These students may not even be aware of the unintentional side effects of their behavior. A gentle,

diplomatic discussion might encourage them to foster a more balanced class dynamic.

8). Slackers

On the opposite end of the spectrum, we find ‘slackers’ – students who often don’t respond to roll calls, arrive late, or only show up for tests and exams. They’re frequently viewed as problematic groupmates for projects. Understanding the root cause of their behavior is critical. Researchers like Finn (1989) argue that slacking off could be a sign of underlying issues, including familial problems, learning disabilities, or mental health concerns. When such issues are suspected, it may be prudent to recommend them to school counseling or psychological services for additional support.

9). Shy Ones

Shy students are often punctual and regular in attendance but may not participate actively in class activities. They tend to stay within their comfort zones, speaking infrequently, and appear hesitant to share their thoughts openly.

Helping shy students open up may require a patient, gradual approach. Gillies (2008) suggests that using humor can establish a relaxed classroom environment, which can help shy students feel comfortable. Providing positive reinforcement targeting their good performance can help boost their confidence (Hattie & Timperley,

2007). Such feedback may reduce anxiety and eventually inspire more active participation.

10) Class Clowns

Class clowns can bring a sense of levity to even the most serious classroom atmospheres with their jokes and antics. However, these comedic interjections can sometimes disrupt the flow of learning, causing distraction among peers.

Responding to class clowns requires a careful, strategic approach. Rather than reacting in frustration or anger, educators could help the student understand that their behavior, although entertaining, may not always be appropriate in the classroom context (Ruch et al., 2014). Offering alternatives for using their humor constructively can redirect this energy while maintaining classroom decorum.

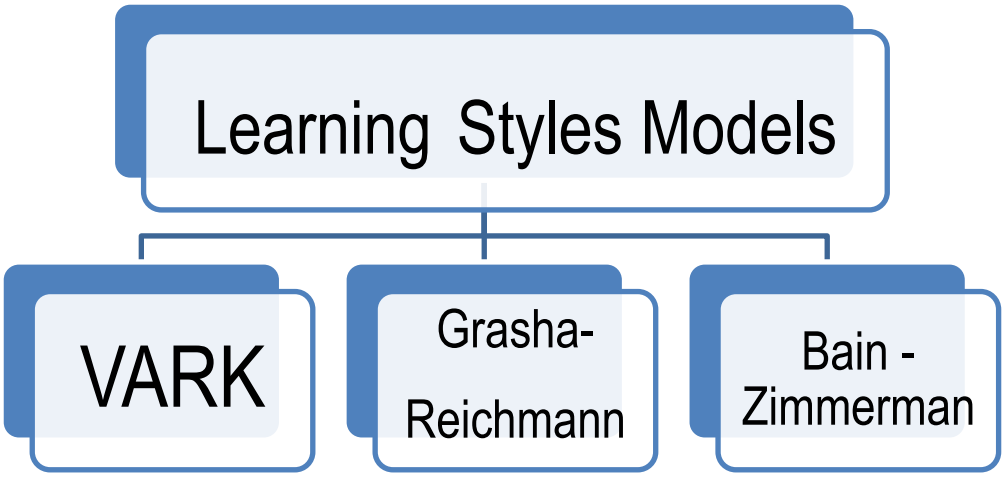
It is important to remember that students are not bound by these categories. They are nuanced individuals whose behaviors can be influenced by a multitude of factors. Understanding these personas provides a stepping stone to crafting individualized educational strategies that cater to each student's unique needs and characteristics.

- *What are your classroom management strategies? How do you deal with disruptions, distractions, or other challenging behaviors? Share your experiences and suggestions below.*

Individual's Learning Style

An individual's learning style refers to the preferential way in which the student absorbs, processes, comprehends and retains information. Individual learning styles depend on cognitive, emotional and environmental factors, as well as one's prior experience.

Learning styles Definition: They are overall patterns that provide direction to learning and teaching. Each learner has distinct and consistent preferred ways of perception, organization and retention.

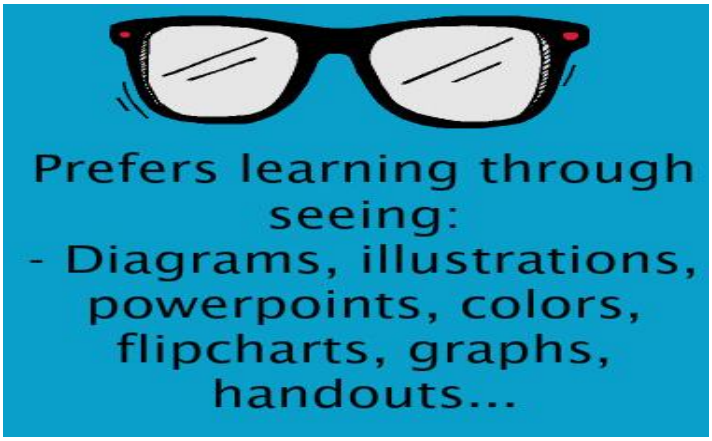


The VARK Model

- acknowledges that students have different approaches to how they process information, referred to as "preferred learning modes."

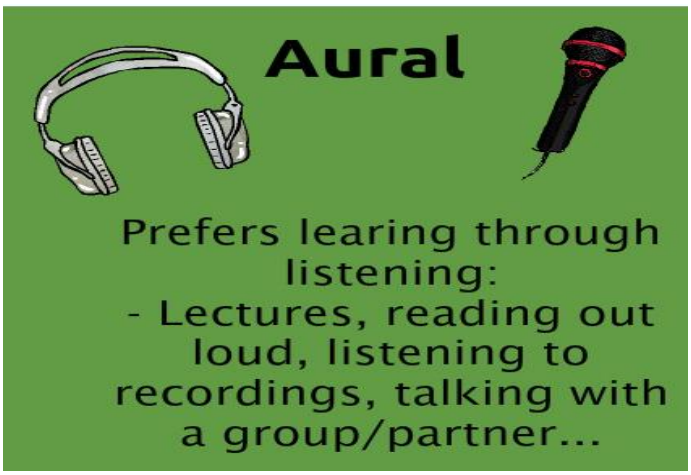
- are found within educational theorist Neil Fleming's VARK model of Student Learning.
- VARK is an acronym that refers to the four types of learning styles: Visual, Auditory, Reading/Writing Preference, and Kinesthetic.

- **Visual learners**: Prefer the use of images, maps, and graphic organizers to access and understand new information.

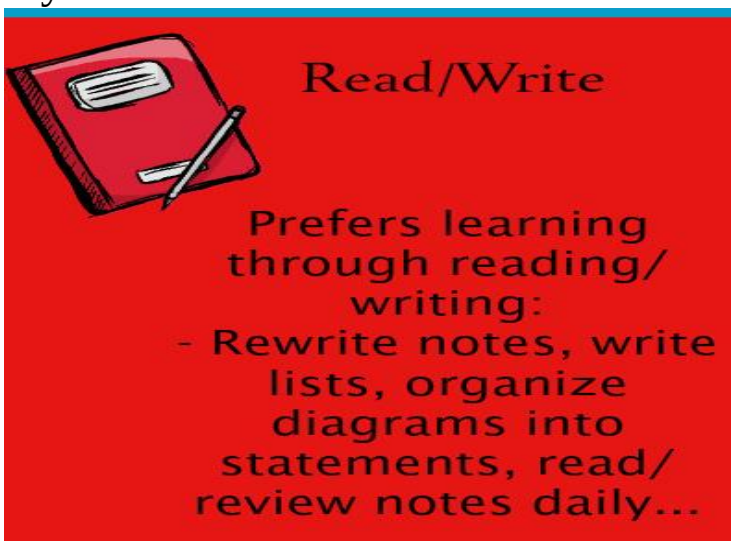


- **Auditory (Aural) Learners**: Best understand new content through listening and speaking in situations such as lectures and group discussions. Use repetition

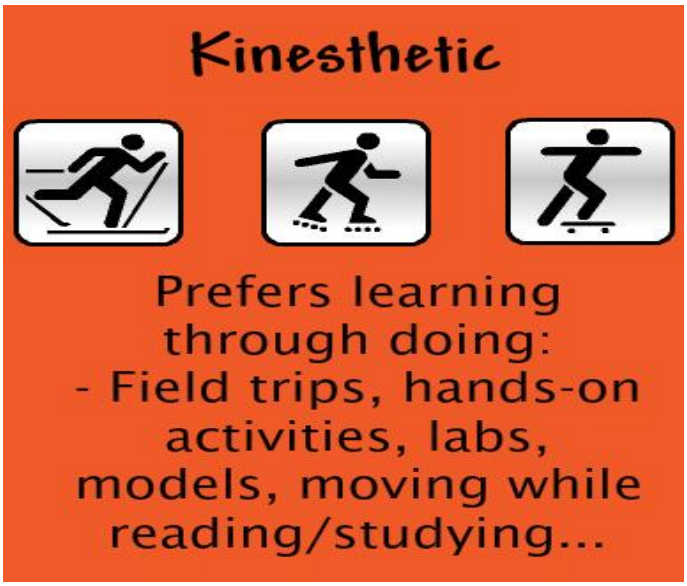
as a study technique and benefit from the use of mnemonic devices.



- Read & write Learners: Learn best through words. These students may present themselves as copious note takers or avid readers, and are able to translate abstract concepts into words and essays



- **Kinesthetic Learners**: Best understand information through tactile representations of information. These students are hands-on learners and learn best through <u>figuring things out by hand</u>.



The Grasha-Reichmann model

- It focuses on student attitudes toward learning, classroom activities, teachers, and peers rather than studying the relationships among methods, student style, and achievement.

Independent Student

- like to think for themselves
- confident in their learning abilities
- choose to work alone on projects than with others
- likes a maximum of choice and flexibility, minimum of structure

Avoidant Student

- do not participate
- uninterested and/or overwhelmed
- does not want to be called on in class

Collaborative Student

- learn by sharing ideas
- cooperate and like to work with others
- likes discussion in class and group projects

Dependent Student

- little intellectual curiosity
- learn only what is required

- view teacher and peers as sources of structure and support
- look for authority figures to set guidelines
- likes clear deadlines and instructions.

Competitive Student

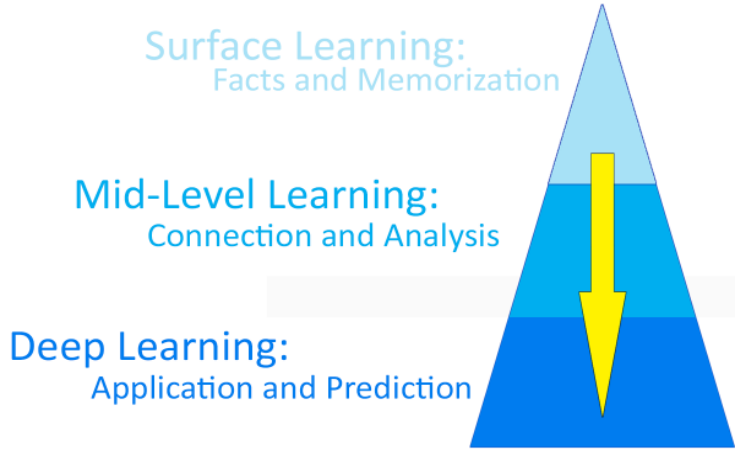
- learn material in order to perform better than others
- feel must compete for rewards
- like to be centre of attention and receive recognition for their accomplishments

Participant Student

- good citizens and enjoy going to class
- take part in course activities as much as possible
- eager to do the required and optional requirements

Bain -Zimmerman Model

Three categories of feelings that students have toward their studies, and the strategies they use to learn, are called “surface”, “strategic” and “deep learners”.

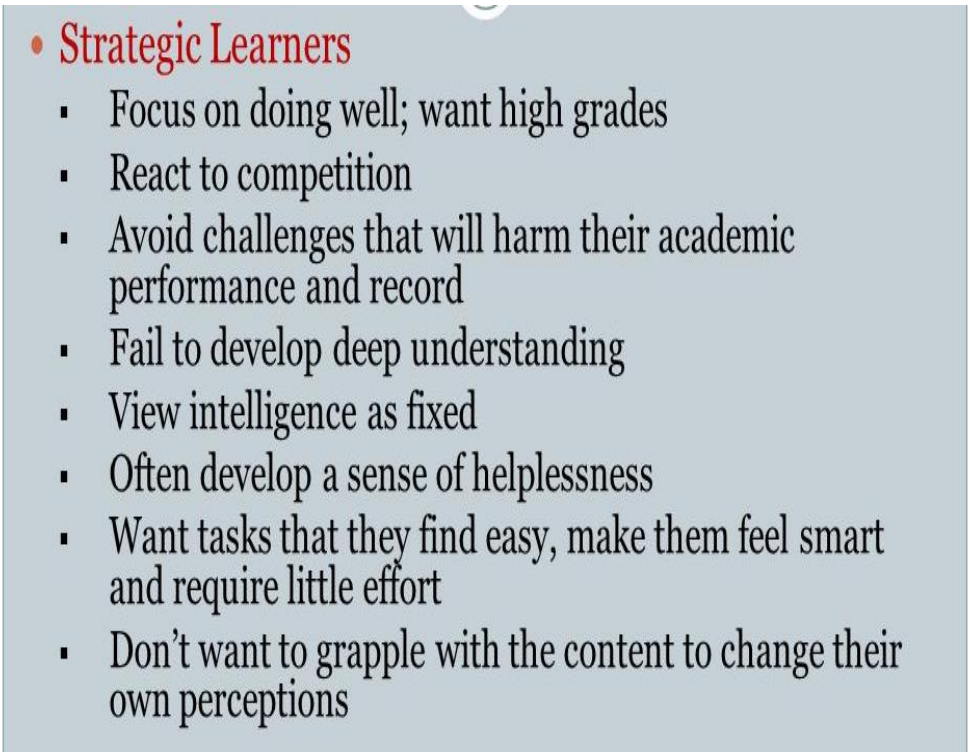


Surface Learners

- Fear of failure and simply try to survive academically.
- They try to replicate what they encounter.
- Because they understand little, they complain on the exam.
- concentrating purely on assessment requirements
- accepting information and ideas passively
- memorizing facts and procedures routinely
- Failing to reflect on underlying purpose or strategy.

Strategic Learners

- want high grades, and will typically spend time trying to find out what the teacher will ask them.
- putting steady effort into study
- seeking out the right conditions and materials
- knowing the requirements and criteria of assessment



Deep Learners

- concerned with understanding, with how to apply their ideas to consequential problems, with implications, and with ideas and concepts.
- make a serious attempt to turn other people's ideas into their own personalized structure of knowledge.
- endeavoring to understand material for themselves
- relating ideas to previous knowledge and experience
- relating evidence to conclusions

Deep learning	Surface learning	Strategic learning
Actively seek to understand the material/the subject	Try to learn in order to repeat what they have learned	Intend to obtain high grades
Interact vigorously with the content	Memorize information needed for assessments	Organise their time and distribute their effort to greatest effect
Make use of evidence, inquiry and evaluation	Take a narrow view and concentrate on detail	Ensure that the conditions and materials for studying are appropriate
Relate new ideas to previous knowledge	Fail to distinguish principles from examples	Use previous exam papers and assessments to predict questions
Tend to read and; study beyond the course requirements	Tend to stick closely to the course requirements	Uses marking criteria carefully
Are motivated by interest	Are motivated by fear of failure	Motivated by grades

Information Processing Theory

Technology has advanced over the decades, taking us to today's information age. Now, modern operations and solutions have become driven by information and communication technologies. In fact, data creation, usage, distribution, and manipulation have become critical in various industries. These are considered transformative elements that influence outcomes, strategies, performance, and returns of institutions.

With this, it is important to be aware of how information is processed and consumed. The information processing theory describes how individuals record, store, and retrieve information in their brains. This affects the motivation and the behavior of a person (Hann et al., 2007). Consequently, the actions and behavior of individuals influence society as a whole.

Information processing theory is an approach to cognitive development studies that aims to explain how information is encoded into memory. It is based on the idea that humans do not merely respond to stimuli from the environment

The process begins with receiving input, also called stimulus, from the environment using various senses. The input is then described and stored in the memory, which is retrieved when needed. The mind or the brain is likened to a computer that is capable of analyzing information from the environment. Even at a young age, a person can amass and store significant volumes of information, as seen in the information processing theory child development.

Consequently, information processing affects a person's behavior (Hann, Hui, Lee, & Png, 2007). In the expectancy theory of motivation, an individual processes information about behavior-outcome relationships. Then, they can form expectations based on the information and make decisions, thus underscoring what is information processing in psychology and its significance.

Origins of Information Processing Theory

George Armitage Miller was the first to put forth the idea of the theory of information processing. He was one of the original founders of cognition studies in psychology and considered a progenitor of the information processing model in psychology. His studies are based on Edward C. Tolman's sign and latent learning theories, which propose that learning is an internal and complex process which involves mental processes (Çeliköz, Erisen, & Sahin, 2019).

Miller discovered the capacity of the working memory, which can generally hold up to seven plus or minus two items. Additionally, he coined the term "chunking" when describing the functionalities of short-term memory.

Aside from Miller, John William Atkinson and Richard Shiffrin are also associated with the information processing approach in cognitive psychology. The Cognitive Information Processing Theory refers to the proposed multi-stage theory of memory, which is one of the leading models of information processing theory (Sala, 2007).

Two other psychologists, Alan Baddeley and Graham Hitch made significant contributions to the information processing theory in psychology through their own studies.

They presented a more in-depth information processing model of memory with various stages, such as visuospatial sketch pad, phonological loop, and central executive (Baddeley, 2006).

Elements of Information Processing Theory

While major models of information processing theory vary, they are mostly composed of three main elements (Çeliköz, Erisen, & Sahin, 2019):

1. **Information stores** The different places in the mind where information is stored, such as sensory memory, short-term memory, long-term memory, semantic memory, episodic memory, and more.
2. **Cognitive processes** The various processes that transfer memory among different memory stores. Some of the processes include perception, coding, recording, chunking, and retrieval.
3. **Executive cognition** The awareness of the individual of the way information is processed within him or her. It also pertains to knowing their strengths and weaknesses. This is very similar to metacognition.

Limitations of Information Processing Theory

Just like any theory, the information processing theory has its limitations. While the presented models adequately describe how information is processed, several issues arise as well:

Analogy Between Computer and Human is Limited

The information processing theory likens the mind to a computer due to the following aspects:

1. Combining or connecting new information with stored information reveals new information that can provide solutions to various problems.
2. A computer has a central processing unit which has limited computing power. Similarly, the central executive in humans has a limited capacity that affects the human attentional system.

One of the obvious limitations of this analogy is the capacity of the human brain to store information that is on the order of 108432 bits. That means the capacity of human memory is excessively better than a computer's (Wang, Liu, & Wang, 2003). This quantity gap between a computer and a human brain means the latter can accommodate processes that the former simply cannot, forming the idea behind the information processing theory of intelligence. Also, the analogy also does not consider the motivational and emotional factors that affect a human's cognition.

What Are the 3 Types of Information Processing Theory?

Let's take at the three types of information processing theory:

1. **Serial Processing Theory:** This theory proposes that information is processed one step at a time in the order received.[3] Each piece of information is held in short-term memory until the next piece of information comes in, and then it is transferred to long-term memory or discarded if it is no longer relevant.
2. **Parallel Processing Theory:** This theory suggests that multiple pieces of information can be processed simultaneously instead of sequentially.[3] It argues against the concept of a limited capacity for short-term

memory since various pieces of information can be stored and processed simultaneously.

Hierarchical Processing Theory: This model suggests that different levels of complexity exist within cognitive processes, with higher-level tasks requiring more complex mental operations than lower-level tasks.[4] This theory developed as a result of Miller's work on the limited capacity of short-term memory and has been used to explain cognitive phenomena such as learning, problem-solving, and decision-making

What Are Some Examples of Information Processing in Daily Life?

Information processing theory has been a handy tool for understanding the cognitive processes involved in acquiring, storing, and using knowledge.

By studying different types of information processing as well as examining real-world examples of them in action, we can better understand how our minds work and why certain tasks require more effort than others.

This knowledge is invaluable for improving educational practices and designing better problem-solving techniques.

1. **Driving:** When driving, you must be constantly aware of your surroundings and use information from all of your senses to respond quickly and accurately to any potential dangers. This requires processing multiple pieces of sensory information in parallel to make safe decisions when behind the wheel.
2. **Learning a Language:** When learning a new language, you must first encode new words in short-term memory

before transferring them into long-term memory through rehearsal and repetition. This process involves both serial and parallel processing as you are encoding new words while also rehearsing previously learned words at the same time.

3. **Problem-Solving:** Problem-solving often involves hierarchical processing as different levels of complexity are required for different tasks. For example, when solving a complex math problem, you may need to break it down into smaller components in order to understand each part and how they all fit together.

What Are the Four Stages of Information Processing Theory?

Information processing theory proposes that cognitive processes happen in four distinct stages, each with its own purpose and functionality.

1. **Encoding:** This is the process of taking in information from the environment and assigning meaning to it.[5] It involves perceiving or attending to stimuli before they can be stored in short-term memory.
2. **Storage:** This is when information is held temporarily in short-term memory while it is processed or transferred into long-term memory for more permanent storage.[5]
3. **Retrieval:** This stage focuses on accessing previously stored information from either short-term or long-term memory in order to utilize it for a current task.[5]
4. **Transformation:** The final stage involves transforming information into a more useful form, such as organizing it in different ways or using reasoning and problem-solving skills to come up with a solution.

Why Is Information Processing Theory Important?

Information processing theory is an important tool for understanding cognitive processes and the way humans acquire, store, and use knowledge.

By examining different types of information processing as well as real-world examples of them in action, we can better understand how our minds work and why certain tasks require more effort than others.

It Can Help Improve Education Overall

This knowledge is invaluable for improving educational practices and designing better problem-solving techniques.

Furthermore, this theory has been used to explain a variety of complex phenomena such as learning, decision-making, and information recall. In short, it provides us with valuable insight into the inner workings of our minds that can be used to improve education in many different areas.

Limitations of Information Processing Theory

It is important to note that information processing theory is not without its limitations and criticisms.

- **The theory ignores emotion and creativity:** One of the main issues with this theory is that it relies too heavily on a computer-like model of how our brains work, which fails to take into account certain aspects such as emotion and creativity.
- **The theory may be too simple:** Additionally, some argue that the four stages are too simplistic and do not

accurately represent the complex processes involved in acquiring knowledge.

Despite these critiques, however, information processing theory remains an invaluable tool for understanding cognitive processes and improving educational practices.

How Can We Apply Information Processing Theory?

Information processing theory can be applied in a variety of different ways. For example, it can help provide insight into how students learn and how best to structure educational material for maximum comprehension.

Additionally, it can be used to improve problem-solving techniques, as well as understand why certain tasks are more difficult than others and develop strategies that make them easier to complete.

What Is the Psychology of Learning?

How Can I Improve My Information Processing Skills?

Improving your information processing skills requires practice and dedication. Here are a few tips that can help you improve your ability to process information:

- Utilize memory techniques such as mnemonic devices and chunking in order to better remember the material.
- Take notes while studying or reading in order to reinforce important concepts.
- Break up complex tasks into smaller, more manageable chunks instead of trying to tackle them all at once.

- Make use of various visual aids such as charts, diagrams, and illustrations; these can make complex topics easier to understand.
- Stay focused on the task at hand by eliminating distractions and setting aside enough time for adequate concentration.

By following these tips and consistently practicing your information processing skills, you can significantly improve your ability to acquire, store, and use knowledge.

Summary

In conclusion, understanding the principles of information processing theory is essential for gaining insight into how our minds work and making use of this knowledge to improve educational practices and increase learning efficiency.

Attention

“Attention is vitality. It connects you with others. It makes you eager. Stay eager.” ― Susan Sontag

Attention is key for both growth and development, especially in young kids. There could be several distractions like the child who is overly sensitive to sensory input may over-respond to the slightest sounds, textures, sights, scents, tastes, or motions. They tend to struggle to attend to simple commands.

Other children might be able to focus with ease when their concentration is challenged. Inattention can lead to indifference, disregard, forgetfulness, carelessness, disinterest, neglect, or thoughtlessness.

When a child is struggling to complete tasks, ***lack of attention*** could be one of the many reasons and as a parent or an educator, it is important to work towards this and help the child.

ave you ever been to a circus? With magicians pulling out one magic trick after the other, acrobats dazzling the audience with their stunts, and jugglers juggling all kinds of objects, a circus is truly an experience.

What is it that makes these performances astounding? The performers are undoubtedly talented. But the key to their success is their sharp and undying focus. The performers are aware that even a momentary loss in focus can cost them not just the performance, but even their lives.

This laser-sharp focus is a result of sustained undivided attention. Did you know that there are different types of attention in psychology that explain our ability to focus on something? Want to learn more about the various kinds of attention? Read on!

What Is Attention?

The concept of 'attention' is an area of study under cognitive psychology. Attention refers to one's ability to select and focus on relevant stimuli. In other words, it's how we actively process information in our environment and tune out information, perceptions and sensations that aren't relevant at the moment.

For example, many people often work in their favorite coffee spots. Although there are many distractions in a public place such as the crowd, the staff and even the bustling noise of the traffic, people remain focused on their work. Their attention allows them to concentrate on the things that are important to them. As you can see, attention can help us focus as well as ignore information around us.

In order to understand how attention works, let us look at its key aspects:

- **Limited:**

  Attention is limited both in terms of capacity and duration

- **Selective:**

  Since attention is limited, we need to be selective about what and where to focus

- **Cognitive:**

  Attention is part of our cognitive system and aids in our ability to survive

What Are The Types Of Attention?

As we've already established, attention is a dynamic phenomenon that changes according to the immediate environment. It's a complex process that's rooted in various cognitive functions. Over the years, researchers have identified various types of attention in psychology. Understanding the different types of attention is the key to being more efficient.

Let us understand the different types of attention and their implications.

1. Focused Attention: This is when we are paying attention and not distracted by external stimuli. Here, people can channel their complete attention on a single task, and everything else is considered less important. It is also called **Executive attention** which blocks unimportant features of the environment. It is the attention we use when we are moving towards a particular end.

Example: Studying for an exam or working on a project.

2. Sustained Attention: It means concentrating on a certain time-consuming task. Holding attention over a period of time is necessary for the focus and concentration needed in learning, listening during lectures, or paying attention during conversations or instructions.

There are three stages of sustained attention which is called one Attention Span:

· **Paying Attention** − Where you start focusing.

· **Keeping Attention** − Where you sustain your attention.

· **Ending attention** − When you finally stop paying attention.

Once your attention ends, you will need time to focus again and remove distractions. Hence, you might notice that people get distracted and often leave the task incomplete, and return after they can refocus after some time. People can get better at sustained attention as they practice it.

Example: Reading a book, watching a magic trick, or watching an interesting movie. As reading requirements become more advanced in the older grades, sustained attention is challenged by chapter books and reading comprehension.

3. Selective Attention: It is when we block out certain features of our environment and focus on one particular feature. It means focusing on a single stimulus in a complex setting.

We must have the ability to focus on a particular message or object by filtering all background noise. But the problem is that people tend to neglect what is going

around (even if it’s important). Hence, the message can easily be manipulated or misunderstood due to communication issues.

Consciously, and unconsciously, we are able to select the input which is most important. Having the ability to select from the many points of visual, auditory, interoceptive, and tactile stimuli in order to focus and attend to just one, is the brain’s ability to select and respond to just one factor that matters most.

Example: Listening to a conversation with a lot of surrounding noise and picking up certain parts. This is because you are choosing to focus on this one person's voice, as opposed to other surrounding distractions like other’s people voices. Another example can be a student listening to their teacher during a lesson while a lawn mower is running outside the classroom window.

4. Divided Attention: It refers to one’s ability to focus on two or more things at the same time. Multitasking is not always an easy thing to manage. The ability to hold attention to various simultaneous points of concentration can require practice.
Some instances of divided attention are easier to manage than others. For example, texting while you are trying to talk to someone in front of you is much more difficult. For kids, it can be holding a conversation while they are playing. Age, agility, the degree of adaptation, and other factors impact this ability.

Example: Simultaneously concentrating on various factors like driving and holding a conversation simultaneously. Another example is talking to a friend on the phone while you're straightening up the house.

5. Alternating Attention: This refers to the ability to switch or immediately transfer focus from one activity to another. Switching points of concentration are needed to make sudden switches in alternating attention in tasks that require different cognitive skills.

Alternating attention requires the ability to use the other attention types in tasks. Here the mind should be flexible and quick to understand and translate every piece of information gathered.

Example: Teachers and parents excel in alternating attention.

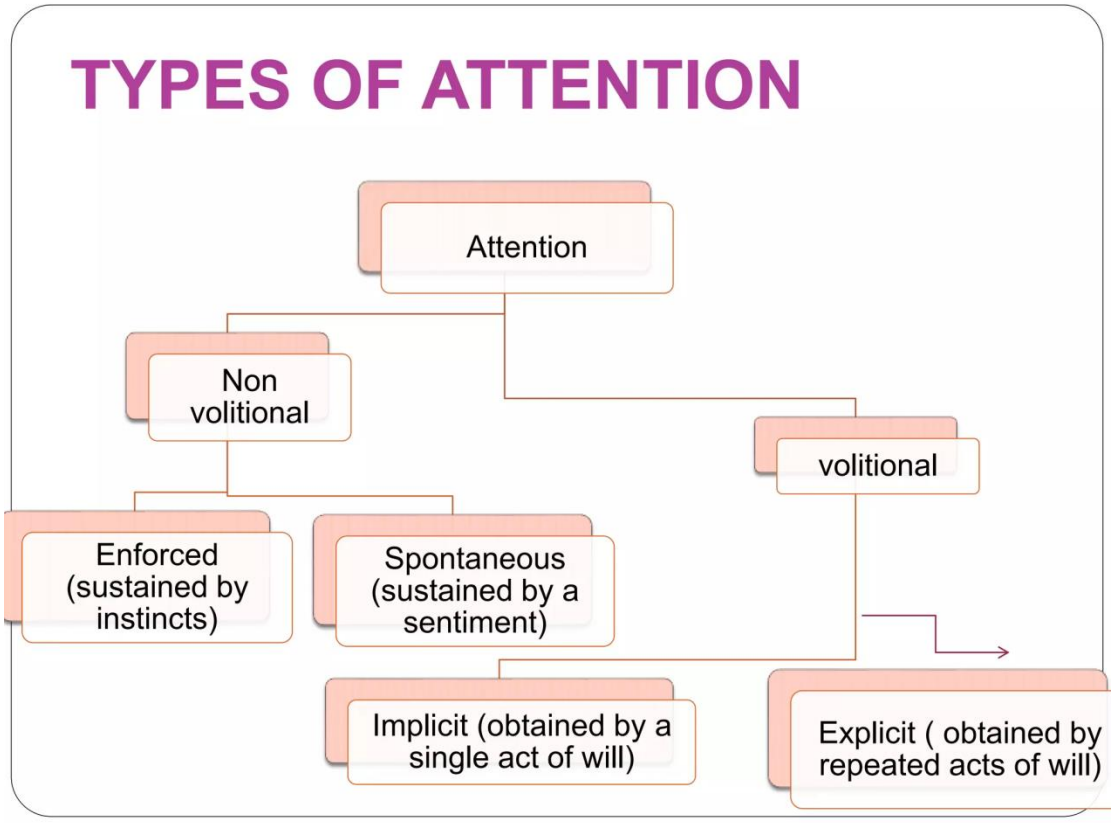
Attentional Blink: According to a theory, attention is just like vision. When we try to visualize two targets at the same time, one of them appears sharp while the other one gets blurred. Similarly, when people focus on two targets at the same time, they tend to miss the second one. When these targets are linked with strong emotions, it becomes easier to reduce attention blink.

*(Source: **https://www.tutorialspoint.com/**)*

Related: https://harappa.education/harappa-diaries/types-of-attention-in-psychology/

Types of Attention:

Ross divides attention into two types – non volitional and volitional, depending upon the need for either an instinct or a deliberate action of will.



Attention Non volitional Enforced (sustained by instincts) Spontaneous (sustained by a sentiment) volitional Implicit (obtained by a single act of will) Explicit (obtained by repeated acts of will)

Non volitional or involuntary attention: This type of attention is aroused without the play or will. We attend to an object or an idea without making any conscious efforts on

our part. For example: Mothers attention towards her crying child , Sudden loud, noise, Bright light.

It is further divided into two types: (A) Enforced attention (B)Spontaneous attention . Involuntary or non volitional attention aroused by the instincts is called enforced non volitional attention. For example, giving attention out of curiosity. Responding to a cinema song while listening to a lecture.

Non volitional attention aroused by sentiments is called spontaneous non volitional attention. For example, we give an automatic or spontaneous attention to an object, idea or a person around which our sentiments are formed.

Volitional or voluntary attention

Ii is demands a conscious effort on our part. For example, solving an assigned problem in mathematics or answering a question in an examination needs voluntary attention. It is further subdivided into categories: (A) Implicit volitional attention (B) Explicit volitional attention

- (A) **Implicit volitional** attention: A single act of will is responsible for arousing attention. For example, a teacher assigns practice work to a child and warns of punishment if not completed. This can make him exercise his will power, attend to the assigned task and finish it properly.
- (B) **Explicit volitional attention**: Attention is obtained by repeated acts of will. One has to struggle hard

keeping oneself attentive; for example, the attention paid during examination days for securing good grades.

Determinants of Attention

- Attention can be influenced by both external and internal factors.
- **A) External Factors**: These are the factors which are external in nature and are usually governed by the characteristics of the stimuli. These external factors could be related to the nature of the stimuli, the intensity as well as the size of the stimuli, the degree to which contrast, variety or change is present in the stimuli.
- The extent to which the exposure to a stimulus is repeated will, also determine the **strength of the attention.** Moreover, a stimulus which is in a state of motion will be able to catch our attention more quickly than a stationery one.
- **B) Internal (Subjective) factors**: The subjective factors which influence attention are *interests, motive, mind set and our attitudes & moods*. It is believed that interest is the mother of attention, as we pay attention or focus on those objects about which we have interest.

DETERMINANTS OF ATTENTION

EXTERNAL FACTORS	INTERNAL FACTORS
Nature of the stimulus	Interest
Intensity and size of the stimulus	Motives
Contrast change and variety	Mental set up
Repetition of the stimulus	Attitude
Movement of the stimulus	Mental and physical state
Location of the stimulus	Value and purpose of the stimulus
Definite form of the object	Prior experience and training
Isolation of stimulus	Habits and temperament
	Instincts and emotions.

External factors:

Nature of stimulus: All types are not able to evoke the same degree of attention. An attractive stimulus should always be chosen for capturing maximum attention. A picture attracts attention readily than words. Among the pictures the pictures of human beings especially beautiful women or handsome men capture more attention.

Intensity of the stimulus: In comparison to a weak stimulus, an intense stimulus attracts more. Our attention is easily directed to a loud sound, a bright light or a strong smell. Size of the stimulus: As a rule bigger size objects in the environment are more likely to catch

our attention than a small object. A small size on a very big background also attracts attention.

Contrast change and novelty: Change and variety strike attention more easily than routine. The use of maps and charts suddenly attracts the students than a verbal talk. Novelty means something new or different. It attracts attention very easily and is closely related to change. location of stimulus: The location of the stimulus also affects attention. For example, advertisements given in front page or on the upper half of any page attract more attention.

Repetition of stimulus: A repeated stimulus attracts our attention. We ignore a stimulus at first instance but, when it is repeated several times, it captures our attention. Movement of stimulus: A moving stimulus catches our attention more quickly than a stimulus that does not move. This is why the pictures on a television or cinema holds our attention for hours at time.

Definite form of the object: A sharply defined object attracts our attention more than a broad indefinite object. A figure attracts more attention than the background. Isolation of stimulus: Isolation is an important external determinant of attention. A student sitting alone in the corner of the class is seen first.

Internal Factors

Interest and attention: Interest is a very helpful factor in securing attention. We attend to in which we are interested than those in which we are not interested.

Motives : The basic drives and urges of the individual are very important in securing attention. Thirst, hunger, sex, curiosity, fear are some of the important motives

Mental set up : A person always attends to those objects towards which his mind has set. Foe example, on the day of examination the slightest thing concerning the examination easily attracts the attention of the students.

Past experience: Learning and previous experience facilitate attention. If we know by our past experience that a particular person is sincere to us, we pay attention to whatever he advices.

Emotion: the emotional state in which a person determines attention. For example, a person attends only to bad qualities of his enemy. Habit : It is also important determinant of attention. A man develops the habit of attending to necessary and desirable things and on the other hand develops a habit of not attending to necessary and undesirable things.

Aim : every man has some immediate and ultimate aims. So a student whose aim is to pass the examination will at once attend to the textbooks or notes.

Meaning : In comparison to meaningless stimuli, meaningful stimulus attracts more attention.

Disposition and temperament: Both are important internal factors which attracts attention. For example, a man having a religious disposition and spiritual temperament will attend to religious matters.

Duration And Degree Of Attention

The maximum amount of material that can be attended in one period of attention is called span of attention or degree of attention. This can be visual or auditory attention.

 Span of visual attention: Experiments have been carried to measure the span of attention by making brief exposures to a number of objects. The time of exposure is very short, ranging from 1/100 to 1/5 of a second. The objects exposed to the eyes are simple like dots, lines, letters,or complex words or triangles etc..

 Span of auditory attention: The number of auditory impressions perceived at a single instances is called span of auditory attention. An adult can perceive eight sounds given rapidly in succession. But when sounds are given in a rhythm, a much larger number of sounds can be perceived.

Duration of attention: It refers to how one can attend to an object without a break. If we attend to a single, simple object for instance a dot it will remain in the focus of our consciousness for only a second at the most, then something in the margin will crowd it out or memory of a past event will intrude. Sustained attention: To sustain attention is to concentrate one's activity continuously upon some object or a happening or a problem.

Shifting of attention While paying attention towards an object or an event, it is not possible to hold attention continuously with the same intensity for an longer duration. Its continuously shifting from one object to another, from one aspect of the situation to another.

Educational Implications:

- Non-Volitional Attention: The earliest form of attention is the non- volitional, especially the instinctive non-volitional, or the enforced non-volitional. The child cannot resist looking at a moving object, out of curiosity. If he sees a camel for the first time; all his attention will be directed towards the camel.
- The teacher should make most of the instinctive attention by exploiting his instincts of curiosity and constructiveness. But he cannot go too far in this direction. He shall have to call in the spontaneous non-volitional attention governed by the sentiments. If the teacher can aid the pupil, build sentiments round the

particular subjects, activities and hobbies and then make appeal to these acquired dispositions, there is no problem of creating attention.

- The pupils will attend spontaneously to the subjects and activities of their choice. But there is limit to this type of attention also. All the tasks and subjects in the school curriculum are not pleasant and soft enough to be loved by the pupils. Here volitional attention is necessary. 2. Volitional Attention: There are good many circumstances where the pupil has to enforce his will in order to attend to certain tasks which are no longer interesting, easy and pleasant. In the examination hall, the pupils have to call forth volitional attention.
- A question arises whether the pupils should be made to call forth his will to do certain odd tasks. Some progressive thinkers who make much of the doctrine of interest, would like the teacher to make everything interesting to the pupils, so that non-volitional attention is automatically procured. Soft Pedagogies and Attention: On the one hand, we have the dictum that learning must become purposeful and interesting, and it is the business of the teacher to create interest beginning to teach. On the other hand, there, is a sharp criticism of the soft pedagogies, that in this way teachers will be failing to prepare the pupils for serious adult life. After all, life is not a bed of roses. The serious vocational life pre-supposes completion of both pleasant and unpleasant tasks and acquiring a hard vocational training. There is a halt to the amusement side of teaching at some stage.

The difficult sums of Algebra, the complex rules of Physics, the complicated geographical, economic and historical facts, the illogical instances of English spellings, the abstract rules of grammar — all these require a sustained will to understand and assimilate. Ross offers a compromising formula when he says that volitional attention, too, is sustained by interest.

- The interest factor is not absent in volitional attention. So some amount of drudgery is to be faced in the school, it can be made interesting or concerning to the pupils. If the pupil knows that his present hard work will be wellrewarded in form of distinction in the examinations, admission in the next higher classes (wherein there is a lot of competitions) and further starting of a good career which can make life worth-living, the present hard work really matters to him, howsoever drudgery it be. Even the questions of saving his face at the time of announcement of results motivates him to work. Drudgery accompanied by some sort of motivation (due to sentiment, self-respect or desire to prosper in future) will be well-attended to. The teacher is advised not to strive to make everything amusing and entertaining, but to create interest by any means, and motivate the pupils to work zealously and accomplish all serious and dull tasks.

What Is Memory?

Memory refers to the psychological processes of acquiring, storing, retaining, and later retrieving information. There are three major processes involved in memory: encoding, storage, and retrieval.

Human memory involves the ability to both preserve and recover information. However, this is not a flawless process. Sometimes people forget or misremember things. Other times, information is not properly encoded in memory in the first place.

How Memories Are Formed?

In order to create a new memory, information must be changed into a usable form, which occurs through a process known as *encoding*. Once the information has been successfully encoded, it must be stored in memory for later use.

Researchers have long believed that memories form due to changes in brain neurons (nerve cells). Our understanding today is that memories are created through the connections that exist between these neurons—either by strengthening these connections or through the growth of new connections.[1]

Changes in the connections between nerve cells (known as synapses) are associated with the learning and retention of new information. Strengthening these connections helps commit information to memory.

This is why reviewing and rehearsing information improves the ability to remember it. Practice strengthens the connections between the synapses that store that memory.

Much of our stored memory lies outside of our awareness most of the time, except when we actually need to use it. The memory retrieval process allows us to bring stored memories into conscious awareness.

In this section we will consider the two **types of memory**, *explicit memory* and *implicit memory*, and then the three major **memory stages**: *sensory*, *short-term*, and *long-term* (Atkinson & Shiffrin, 1968). Then, in the next section, we will consider the nature of long-term memory, with a particular emphasis on the cognitive techniques we can use to improve our memories. Our discussion will focus on the three processes that are central to **long-term memory**: *encoding*, *storage*, and *retrieval*.

Table 9.1 Memory Conceptualized in Terms of Types,

Stages, and Processes.

As types	Explicit memory Implicit memory
As stages	Sensory memory Short-term memory Long-term memory
As processes	Encoding Storage Retrieval

Explicit Memory

When we assess memory by asking a person to consciously remember things, we are measuring *explicit memory*. **Explicit memory** refers to *knowledge or experiences that can be consciously remembered*. As you can see in Figure 9.2, "Types of Memory," there are two types of explicit memory: *episodic* and *semantic*. **Episodic memory** refers to *the firsthand experiences that we have had* (e.g., recollections of our high school graduation day or of the fantastic dinner we had in New York last year). **Semantic memory** refers to *our knowledge of facts and concepts about the world* (e.g., that the absolute value of −90 is greater than the absolute value of 9 and that one definition of the word "affect" is "the experience of feeling or emotion").

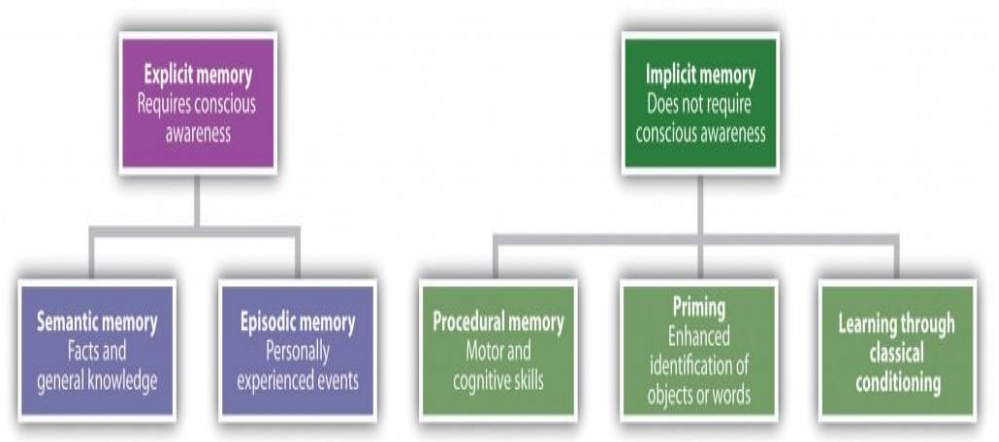


Figure 9.2 Types of Memory.

Explicit memory is assessed using measures in which the individual being tested must consciously attempt to remember the information. A **recall memory** test is *a measure of explicit memory that involves bringing from memory information that has previously been remembered*. We rely on our recall memory when we take an essay test, because the test requires us to generate previously remembered information. A multiple-choice test is an example of a **recognition memory test**, *a measure of explicit memory that involves determining whether information has been seen or learned before*.

Your own experiences taking tests will probably lead you to agree with the scientific research finding that recall is more difficult than recognition. Recall, such as required on essay tests, involves two steps: first generating an answer and then determining whether it seems to be the correct one. Recognition, as on multiple-choice test, only involves determining which item from a list seems most correct (Haist, Shimamura, & Squire, 1992). Although they involve different processes, recall and recognition memory measures tend to be correlated. Students who do better on a multiple-choice exam

will also, by and large, do better on an essay exam (Bridgeman & Morgan, 1996).

A third way of measuring memory is known as *relearning* (Nelson, 1985). Measures of **relearning** (or savings) *assess how much more quickly information is processed or learned when it is studied again after it has already been learned but then forgotten*. If you have taken some French courses in the past, for instance, you might have forgotten most of the vocabulary you learned. But if you were to work on your French again, you'd learn the vocabulary much faster the second time around. Relearning can be a more sensitive measure of memory than either recall or recognition because it allows assessing memory in terms of "how much" or "how fast" rather than simply "correct" versus "incorrect" responses. Relearning also allows us to measure memory for procedures like driving a car or playing a piano piece, as well as memory for facts and figures.

Implicit Memory

While explicit memory consists of the things that we can consciously report that we know, implicit memory refers to knowledge that we cannot consciously access. However, implicit memory is nevertheless exceedingly important to us because it has a direct effect on our behaviour. **Implicit memory** refers to *the influence of experience on behaviour, even if the individual is not aware of those influences*. As you can see in Figure 9.2, "Types of Memory," there are three general types of implicit memory: procedural memory, classical conditioning effects, and priming.

Procedural memory refers to *our often unexplainable knowledge of how to do things*. When we walk from one place

to another, speak to another person in English, dial a cell phone, or play a video game, we are using procedural memory. Procedural memory allows us to perform complex tasks, even though we may not be able to explain to others how we do them. There is no way to tell someone how to ride a bicycle; a person has to learn by doing it. The idea of implicit memory helps explain how infants are able to learn. The ability to crawl, walk, and talk are procedures, and these skills are easily and efficiently developed while we are children despite the fact that as adults we have no conscious memory of having learned them.

A second type of implicit memory is **classical conditioning effects**, in which *we learn, often without effort or awareness, to associate neutral stimuli (such as a sound or a light) with another stimulus (such as food), which creates a naturally occurring response, such as enjoyment or salivation*. The memory for the association is demonstrated when the conditioned stimulus (the sound) begins to create the same response as the unconditioned stimulus (the food) did before the learning.

The final type of implicit memory is known as **priming**, or *changes in behaviour as a result of experiences that have happened frequently or recently*. Priming refers both to the activation of knowledge (e.g., we can prime the concept of kindness by presenting people with words related to kindness) and to the influence of that activation on behaviour (people who are primed with the concept of kindness may act more kindly).

One measure of the influence of priming on implicit memory is the *word fragment test*, in which a person is asked to fill in missing letters to make words. You can try this

yourself: First, try to complete the following word fragments, but work on each one for only three or four seconds. Do any words pop into mind quickly?

_ i b _ a _ y

_ h _ s _ _ i _ n

_ o _ k

_ h _ i s _

Now read the following sentence carefully:

“He got his materials from the shelves, checked them out, and then left the building.”

Then try again to make words out of the word fragments.

I think you might find that it is easier to complete fragments 1 and 3 as “library” and “book,” respectively, after you read the sentence than it was before you read it. However, reading the sentence didn’t really help you to complete fragments 2 and 4 as “physician” and “chaise.” This difference in implicit memory probably occurred because as you read the sentence, the concept of “library” (and perhaps “book”) was primed, even though they were never mentioned explicitly. Once a concept is primed it influences our behaviours, for instance, on word fragment tests.

Our everyday behaviours are influenced by priming in a wide variety of situations. Seeing an advertisement for cigarettes may make us start smoking, seeing the flag of our home country may arouse our patriotism, and seeing a student from a rival school may arouse our competitive spirit. And

these influences on our behaviours may occur without our being aware of them.

Notes: Implicit memories tend to be the most durable form of long-term memory. While explicit memory declines with age, healthy adults typically maintain strong implicit memories as they grow older

Stages of Memory: Sensory, Short-Term, and Long-Term Memory

Another way of understanding memory is to think about it in terms of stages that describe the length of time that information remains available to us. According to this approach (see Figure 9.4, "Memory Duration"), information begins in *sensory memory*, moves to *short-term memory*, and eventually moves to *long-term memory*. But not all information makes it through all three stages; most of it is forgotten. Whether the information moves from shorter-duration memory into longer-duration memory or whether it is lost from memory entirely depends on how the information is attended to and processed.

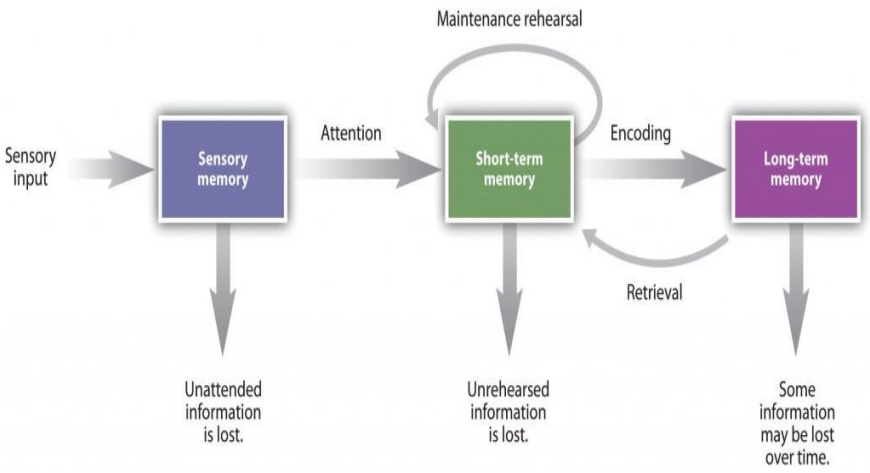


Figure 9.4 Memory Duration. Memory can characterized in terms of stages — the length of time that information remains available to us.

Sensory Memory

Sensory memory refers to *the brief storage of sensory information*. Sensory memory is a memory buffer that lasts only very briefly and then, unless it is attended to and passed on for more processing, is forgotten. The purpose of sensory memory is to give the brain some time to process the incoming sensations, and to allow us to see the world as an unbroken stream of events rather than as individual pieces.

Visual sensory memory is known as **iconic memory**. Iconic memory was first studied by the psychologist George Sperling (1960). In his research, Sperling showed participants a display of letters in rows, similar to that shown in Figure 9.5, "Measuring Iconic Memory." However, the display lasted only about 50 milliseconds (1/20 of a second). Then, Sperling gave his participants a recall test in which they were asked to name all the letters that they could remember. On

average, the participants could remember only about one-quarter of the letters that they had seen.

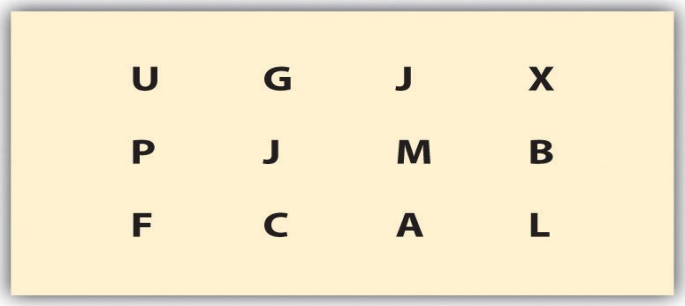


Figure 9.5 Measuring Iconic Memory. Sperling showed his participants displays such as this one for only 1/20th of a second. He found that when he cued the participants to report one of the three rows of letters, they could do it, even if the cue was given shortly after the display had been removed. The research demonstrated the existence of iconic memory.

Sperling reasoned that the participants had seen all the letters but could remember them only very briefly, making it impossible for them to report them all. To test this idea, in his next experiment, he first showed the same letters, but then after the display had been removed, he signaled to the participants to report the letters from either the first, second, or third row. In this condition, the participants now reported almost all the letters in that row. This finding confirmed Sperling's hunch: participants had access to all of the letters in their iconic memories, and if the task was short enough, they were able to report on the part of the display he asked them to. The "short enough" is the length of iconic memory, which turns out to be about 250 milliseconds (¼ of a second).

Auditory sensory memory is known as **echoic memory**. In contrast to iconic memories, which decay very rapidly, echoic memories can last as long as four seconds (Cowan, Lichty, & Grove, 1990). This is convenient as it allows you — among other things — to remember the words that you said at the beginning of a long sentence when you get to the end of it, and to take notes on your psychology professor's most recent statement even after he or she has finished saying it.

In some people iconic memory seems to last longer, a phenomenon known as **eidetic imagery** (or *photographic memory*) in which *people can report details of an image over long periods of time*. These people, who often suffer from psychological disorders such as autism, claim that they can "see" an image long after it has been presented, and can often report accurately on that image. There is also some evidence for eidetic memories in hearing; some people report that their echoic memories persist for unusually long periods of time. The composer Wolfgang Amadeus Mozart may have possessed eidetic memory for music, because even when he was very young and had not yet had a great deal of musical training, he could listen to long compositions and then play them back almost perfectly (Solomon, 1995).

Short-Term Memory

Most of the information that gets into sensory memory is forgotten, but information that we turn our attention to, with the goal of remembering it, may pass into *short-term memory*.

Short-term memory (STM) is *the place where small amounts of information can be temporarily kept for more than*

a few seconds but usually for less than one minute (Baddeley, Vallar, & Shallice, 1990). Information in short-term memory is not stored permanently but rather becomes available for us to process, and *the processes that we use to make sense of, modify, interpret, and store information in STM* are known as **working memory**.

Although it is called memory, working memory is not a store of memory like STM but rather a set of memory procedures or operations. Imagine, for instance, that you are asked to participate in a task such as this one, which is a measure of working memory (Unsworth & Engle, 2007). Each of the following questions appears individually on a computer screen and then disappears after you answer the question:

Is 10 × 2 − 5 = 15? (Answer YES OR NO) Then remember "S"
Is 12 ÷ 6 − 2 = 1? (Answer YES OR NO) Then remember "R"
Is 10 × 2 = 5? (Answer YES OR NO) Then remember "P"
Is 8 ÷ 2 − 1 = 1? (Answer YES OR NO) Then remember "T"

Is $6 \times 2 - 1 = 8$? (Answer YES OR NO) Then remember “U”
Is $2 \times 3 - 3 = 0$? (Answer YES OR NO) Then remember “Q”

To successfully accomplish the task, you have to answer each of the math problems correctly and at the same time remember the letter that follows the task. Then, after the six questions, you must list the letters that appeared in each of the trials in the correct order (in this case S, R, P, T, U, Q).

To accomplish this difficult task you need to use a variety of skills. You clearly need to use STM, as you must keep the letters in storage until you are asked to list them. But you also need a way to make the best use of your available attention and processing. For instance, you might decide to use a strategy of repeat the letters twice, then quickly solve the next problem, and then repeat the letters twice again including the new one. Keeping this strategy (or others like it) going is the role of working memory’s **central executive** — *the part of working memory that directs attention and processing*. The central executive will make use of whatever strategies seem to be best for the given task. For instance, the central executive will direct the rehearsal process, and at the same time direct the visual cortex to form an image of the list of letters in memory. You can see that although STM is involved, the processes that we use to operate on the material in memory are also critical.

Short-term memory is limited in both the length and the amount of information it can hold. Peterson and Peterson

(1959) found that when people were asked to remember a list of three-letter strings and then were immediately asked to perform a distracting task (counting backward by threes), the material was quickly forgotten (see Figure 9.6, "STM Decay"), such that by 18 seconds it was virtually gone.

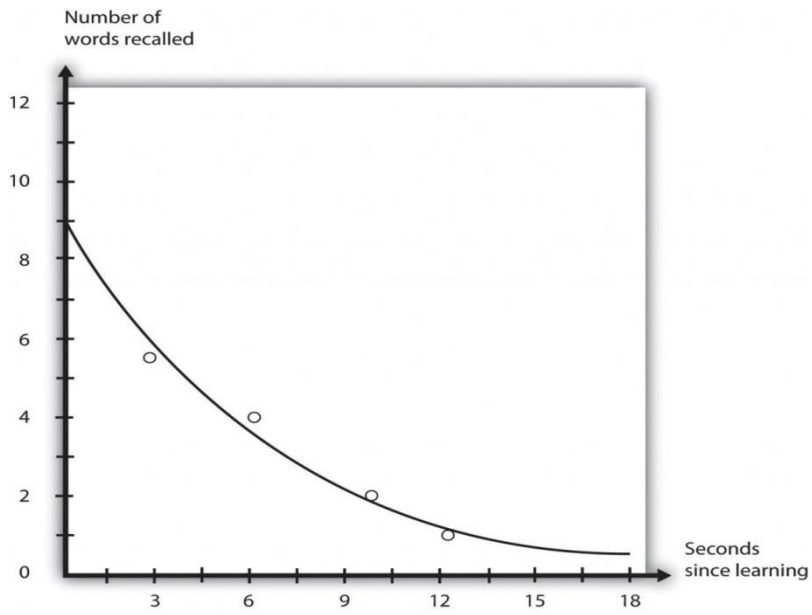


Figure 9.6 STM Decay. Researchers found that information that was not rehearsed decayed quickly from memory.

One way to prevent the decay of information from short-term memory is to use working memory to rehearse it. **Maintenance rehearsal** is *the process of repeating information mentally or out loud with the goal of keeping it in memory*. We engage in maintenance rehearsal to keep something that we want to remember (e.g., a person's name, email address, or phone number) in mind long enough to write it down, use it, or potentially transfer it to long-term memory.

If we continue to rehearse information, it will stay in STM until we stop rehearsing it, but there is also a capacity limit to STM. Try reading each of the following rows of numbers, one row at a time, at a rate of about one number each second. Then when you have finished each row, close your eyes and write down as many of the numbers as you can remember.

019

3586

10295

861059

1029384

75674834

657874104

6550423897

If you are like the average person, you will have found that on this test of working memory, known as a *digit span test*, you did pretty well up to about the fourth line, and then you started having trouble. I bet you missed some of the numbers in the last three rows, and did pretty poorly on the last one.

The digit span of most adults is between five and nine digits, with an average of about seven. The cognitive psychologist George Miller (1956) referred to "seven plus or minus two" pieces of information as the magic number in short-term memory. But if we can only hold a maximum of about nine digits in short-term memory, then how can we remember larger amounts of information than this? For instance, how

can we ever remember a 10-digit phone number long enough to dial it?

One way we are able to expand our ability to remember things in STM is by using a memory technique called *chunking*. **Chunking** is *the process of organizing information into smaller groupings (chunks), thereby increasing the number of items that can be held in STM*. For instance, try to remember this string of 12 letters:

XOFCBANNCVTM

You probably won't do that well because the number of letters is more than the magic number of seven.

Now try again with this one:

CTVCBCTSNHBO

Would it help you if I pointed out that the material in this string could be chunked into four sets of three letters each? I think it would, because then rather than remembering 12 letters, you would only have to remember the names of four television stations. In this case, chunking changes the number of items you have to remember from 12 to only four.

Experts rely on chunking to help them process complex information. Herbert Simon and William Chase (1973) showed chess masters and chess novices various positions of pieces on a chessboard for a few seconds each. The experts did a lot better than the novices in remembering the positions because they were able to see the "big picture." They didn't have to remember the position of each of the pieces individually, but chunked the pieces into several larger layouts. But when the researchers showed both groups random chess positions — positions that would be very

unlikely to occur in real games — both groups did equally poorly, because in this situation the experts lost their ability to organize the layouts (see Figure 9.7, “Possible and Impossible Chess Positions”). The same occurs for basketball. Basketball players recall actual basketball positions much better than do nonplayers, but only when the positions make sense in terms of what is happening on the court, or what is likely to happen in the near future, and thus can be chunked into bigger units (Didierjean & Marmèche, 2005).

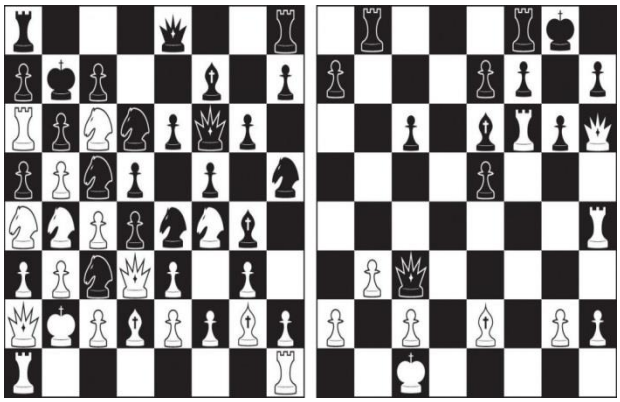
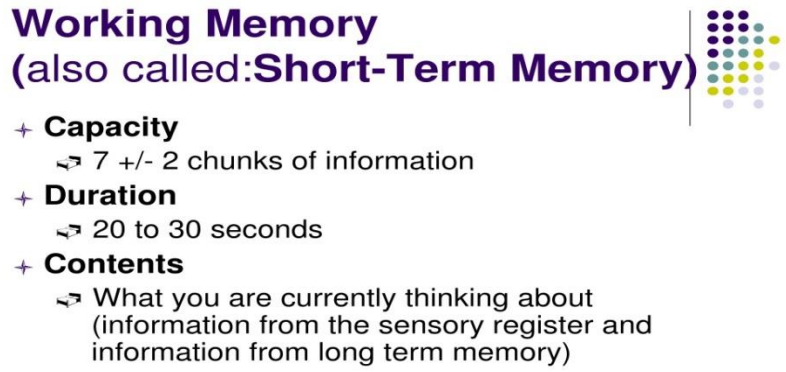


Figure 9.7 Possible and Impossible Chess Positions. Experience matters: Experienced chess players are able to recall the positions of the game on the right much better than are those who are chess novices. But the experts do no better than the novices in remembering the positions on the left, which cannot occur in a real game.



While many of our short-term memories are quickly forgotten, attending to this information allows it to continue to the next stage: long-term memory. Most of the information stored in active memory will be kept for approximately 20 to 30 seconds.

This capacity can be stretched somewhat by using memory strategies such as chunking, which involves grouping related information into smaller chunks.

In a famous paper published in 1956, psychologist George Miller suggested that the capacity of short-term memory for storing a list of items was somewhere between five and nine. Some memory researchers now believe that the true capacity of short-term memory is probably closer to four

If information makes it past short term-memory it may enter **long-term memory (LTM)**, *memory storage that can hold information for days, months, and years*. The capacity of long-term memory is large, and there is no known limit to what we can remember (Wang, Liu, & Wang,

2003). Although we may forget at least some information after we learn it, other things will stay with us forever.

What Is Long-Term Memory?

Long-term memory refers to the transfer of information from short-term memory into long-term storage in order to create enduring memories. This type of memory is unlimited in capacity and stable—lasting for years or even a lifetime. Short-term memories can become long-term memories through a process known as consolidation.

Long-term memory can be further subdivided into two different types: explicit (conscious) and implicit (unconscious) memory. If you can remember something that happened more than just a few moments ago, whether it occurred just hours ago or decades earlier, it is long-term memory.

Long term memory is important because it helps us recall major events in our lives. We also use long-term memory to access the skills and behaviors that we've learned which contribute to our survival.

Types of Long-Term Memory

Long-term memory is usually divided into two types—explicit and implicit.

- **Explicit memories**, also known as declarative memories, include all of the memories that are available in consciousness. Explicit memory can be further divided into episodic memory (specific events) and semantic memory (knowledge about the world).

Examples of this type of long-term memory include being able to recall your high school graduation or remembering the year that the U.S. declared its independence.

- **Implicit memories** are those that are mostly unconscious. This type of memory includes procedural memory, which involves memories of body movement and how to use objects in the environment. Knowing how to drive a car or use a computer are examples of procedural memories.

Long-term memories are often outside of the conscious mind. This information is largely outside of our awareness but can be called into working memory to be used when needed. Some memories are relatively easy to recall, while others are much harder to access.

Duration of Long-Term Memory

Through the process of association and rehearsal, the content of short-term memory can become long-term memory. Long-term memories can last from a matter of days to as long as many decades.

There are a number of factors that can influence how long information endures in long-term memory:

- **The way the memory was encoded in the first place** can play a significant role. If you were very aware and alert when you had the experience, then the memory will probably be a lot more vivid.
- **The number of times you access a memory** can also play a role in the strength and duration of that memory.

Not surprisingly, memories that you recall often tend to stick around and become much stronger.

Not all long-term memories are created equal. While some memories spring to mind quickly, others are weaker and might require prompts or reminders to bring them into focus.

Information that is of greater importance leads to a stronger recall. You can usually remember important events such as your wedding day with much greater clarity and detail than you can more ordinary days.

How Long-Term Memory Forms?

The information-processing model of memory characterizes human memory as being like a computer. Information enters short-term memory (a temporary store), then some of this information is transferred into long-term memory (a relatively permanent store), much like information being saved to the hard disk of a computer.

Memories that are frequently accessed become stronger and easier to recall. Accessing these memories over and over again strengthens the neural networks in which the information is encoded, leading to easier recollection of the information.

When information is needed, it is called forth out of this long-term storage using environmental cues, much like accessing a saved folder on your computer. However, these saved memories can be changed or sometimes even lost altogether. Memories that are not recalled often can sometimes weaken or be replaced by other information.

Related: Proven Techniques to Improve Your Memory

- How long does short-term memory last?
- What type of long-term memory is most resistant to loss?
- How can I improve my long-term memory?

Why We Forget?

Forgetting is a surprisingly common event. Just consider how easy it is to forget someone's name or overlook an important appointment. Why do people so often forget information they have learned in the past?

There are four basic explanations for why forgetting occurs:

- Failure to store a memory
- Interference[9]
- Motivated forgetting
- Retrieval failure

Research has shown that one of the critical factors that influence memory failure is time. Information is often quickly forgotten, particularly if people do not actively review and rehearse the information.

Sometimes information is simply lost from memory and, in other cases, it was never stored correctly in the first place.

Some memories compete with one another, making it difficult to remember certain information. In other instances, people actively try to forget things that they simply don't want to remember.

Related: What Causes Memory Loss

Related :How to Use Mnemonic Devices to Improve Your Memory

Key Takeaways

- Memory refers to the ability to store and retrieve information over time.
- For some things our memory is very good, but our active cognitive processing of information ensures that memory is never an exact replica of what we have experienced.
- Explicit memory refers to experiences that can be intentionally and consciously remembered, and it is measured using recall, recognition, and relearning. Explicit memory includes episodic and semantic memories.
- Measures of relearning (also known as "savings") assess how much more quickly information is learned when it is studied again after it has already been learned but then forgotten.
- Implicit memory refers to the influence of experience on behaviour, even if the individual is not aware of those influences. The three types of implicit memory are procedural memory, classical conditioning, and priming.
- Information processing begins in sensory memory, moves to short-term memory, and eventually moves to long-term memory.

- Maintenance rehearsal and chunking are used to keep information in short-term memory.
- The capacity of long-term memory is large, and there is no known limit to what we can remember.

Exercises and Critical Thinking

1. List some situations in which sensory memory is useful for you. What do you think your experience of the stimuli would be like if you had no sensory memory?
2. Describe a situation in which you need to use working memory to perform a task or solve a problem. How do your working memory skills help you?

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