



**Ministry of Higher Education and Scientific Research
Hamma Lakhdar University of El-Oued
Faculty of Arts and Languages
Department of Arts and English Language**

Introduction to Cognitive Psychology

Lectures for Third-Year English Students

**A Course Submitted in Fulfilment of the Requirements
for the Degree of MCA (University Habilitation)**

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General Introduction

Course Description: Understanding human behaviour has been one of the most perplexing facts for humanity over the centuries. Understanding and predicting human behaviour will help humans exert more control over situations. The cognitive processes that underpin human behaviour are its foundations.

This course is designed to provide a comprehensive overview of the fundamental cognitive processes that guide human behaviour. It will discuss topics related to information-processing mechanisms of the mind, including consciousness, perception, attention, and memory. Emphasis will be placed on thinking, problem-solving, reasoning, and theories of cognitive development. This course will help you solve real-life problems and find the best answers to very challenging questions.

Course Objectives: On completion of the course, the student will be able to:

- demonstrate knowledge of the basic human cognitive processes,
- develop an understanding and appreciation of how a cognitive approach can help us understand our behaviour and experience in our personal or professional lives,
- describe and discuss major concepts in cognitive psychology,
- analyse and critically evaluate theories and empirical studies in cognitive psychology,
- understand the connection between basic and applied research in cognitive psychology,
- apply major concepts and theories of cognitive psychology to real-life problems.

Organisation of the Course Content: The course is organised topically, moving from more basic cognitive processes to more complex ones. Within each topic, we discuss foundational theories and experimental evidence.

Intended Audience: Third-year students (Undergraduate)

Instruction Format: Lecture and in-class discussion

Instructional Time: 1 hour 30 minutes (one lecture per week)

Prerequisite: Not applicable

Coefficient: 1

Credits: 2

Evaluation: Exam 100%

Suggested Reading:

- Bridger Riegler, *Cognitive Psychology*, Pearson Press
- Daniel Reisberg, *Cognition* (4th ed.), W. W. Norton & Company
- John R. Anderson, *Cognitive Psychology and Its Implications* (8th ed.), Carnegie Mellon University
- Kathleen Galotti, *Cognitive Psychology*, Cengage Learning
- Robert Stenberg, *Applied Cognitive Psychology*, Cengage Learning
- Stephen Kosslyn, *Cognitive Psychology*, PHI Press

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1. Introduction to Cognitive Psychology

1.1. Introduction

Man has always wondered about the characteristics of human cognition (brain) and sought to explore its anatomy and functioning. This constituted a big challenge as the human brain is typically hidden, and the mental (cognitive) processes are not observable. Therefore, understanding how humans think and behave has been the interest of many researchers since Aristotle and Plato to the present day. Cognitive psychology is one recent discipline which attempts to find appropriate answers to the above-mentioned questions.

1.2. Definitions

What is cognition?

Cognition descends from the Latin word *cognoscere* “to get to know, recognise.” It is the result of the assimilation form of *com* “together” + *gnoscere* “to know.” There is no consensus among researchers regarding what cognition is. According to some of them, the term cognition refers to:

“All the processes by which the sensory input is transformed, reduced, elaborated, stored, recovered and used,” (Neisser, 1967).

“All the activities and processes concerned with the acquisition, storage, retrieval and processing of information,” (Byrnes, 1996).

In other words, cognition refers to the inner processes and products of the mind that lead to knowing. It includes all mental activities such as attending, perceiving, remembering, symbolizing, planning, reasoning, problem solving, etc. Simply put, cognition is thinking.

What is Cognitive Psychology?

In fact, there is no agreement among psychologists upon a unique definition of cognitive psychology because of its interdisciplinary nature and its ever-growing character. However, many researchers have tried to put definitions, some of which are listed below:

Sternberg (2009) defines cognitive psychology as “the study of how people perceive, learn, remember, and think about information” (p. 2).

Groome (1999) says it is “the study of the way in which the brain processes information. It concerns the way we take in information from the outside world, how we make sense of that information, and what use we make of it” (p.1).

1.3. History of Cognitive Psychology, a brief

Inquiries into human cognition date back to Aristotle’s (384–322 BC) “De Memoria.” However, the true intellectual origins of cognitive psychology began with cognitive approaches to psychological problems at the end of the 19th C and the beginning of the 20th C in the works of the German physician, physiologist, and philosopher Wilhelm Wundt (1832-1920) and the American philosopher and psychologist William James (1842–1910). The former is known today as one of the

founders of modern psychology as he distinguished psychology as a science from philosophy and biology.

Cognitive psychology declined (as an approach) during the first half of the 20th C to the profit of behaviourism thanks to Pavlov, Watson and Skinner. However, the failure of behaviourism to account for complex learning and many other issues relative to the “black box” led to its decline and rise of the “cognitive revolution” in the mid-1950s. Many researchers like Miller (1956), Chomsky (1959) and Simon (1958) began to develop theories of mind to account for human behaviour.

Ulric Neisser is considered the actual founder of cognitive psychology after he published his influential book “Cognitive Psychology” in 1967, which gave this discipline its name. This book gave a new legitimacy to the field. It consisted of 6 chapters on perception and attention and 4 chapters on language, memory, and thought. Following Neisser’s work, another important event was the launch of the journal *Cognitive Psychology* in 1970. This journal has done much to define the field. Since then, cognitive psychology has dominated the field of psychology.

1.4. Basic Assumptions and Principles

Cognitive psychology is built on these basic assumptions and principles:

- cognitive psychology is a pure science, based on laboratory experiments.
- mediational processes occur between stimulus (input) and response (output).
- mental processes can and should be studied scientifically; this helps formulate theories that can be tested using scientific methods.
- internal processes can be described in terms of the rules of the information processing model (inputting, storing, and retrieving data).

1.5. Influences on Cognitive Psychology

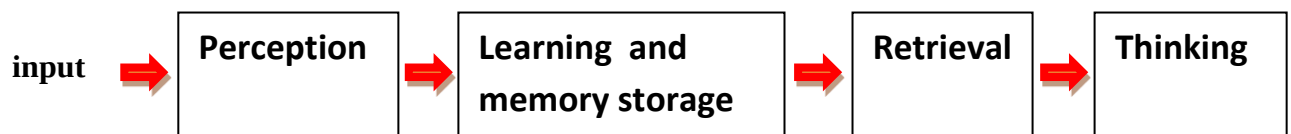
Factors which led to the rise and flourishing of cognitive psychology include the following:

- dissatisfaction with “behaviourism” which stresses external, observable behaviours and rejects internal processes.
- development of cognitive theories and subsequent experimental methods.
- the arrival of the computer, which allowed psychologists to understand the complexities of human cognition by comparing it to a simpler artificial system—computer analogy: typically a computer codes (changes) input (information), stores, uses, produces (retrieves) output.

The emphasis of psychology shifted away from the study of conditioned behaviour and psychoanalytical notions about the study of the mind, towards the understanding of human information processing, using strict and rigorous laboratory investigation.

1.6. Stages of Cognitive Processing

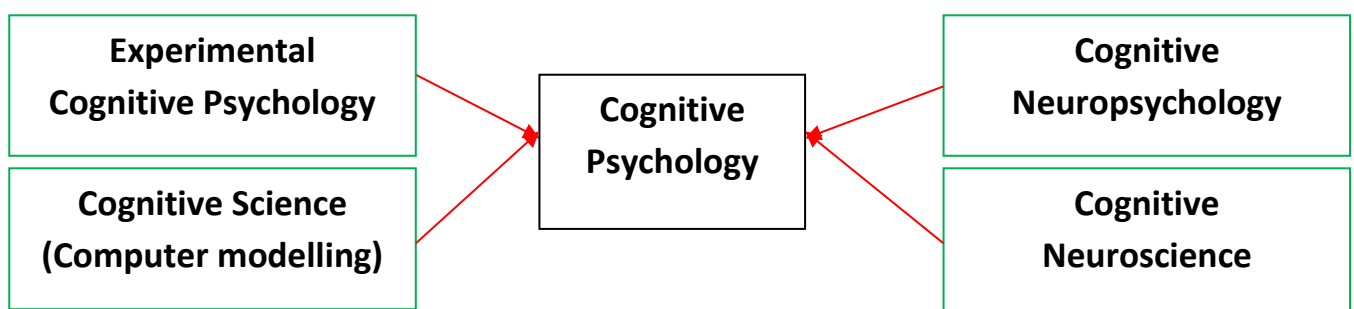
The figure below shows the main stages of cognitive processing which would typically be applied to a new piece of sensory input.



- a- we take in information through our sensory organs.
- b- we analyse the content of this information to make sense of it (perception).
- c- perception leads to some sort of record of the input received (learning and memory strategy) for later use in new settings.
- d- future use of the stored item requires retrieval which is sometimes for its own sake (to access stored information), and sometimes to provide a basis for further mental activities.
- e- retrieval is often used as a part of the thought process (thinking) to help handle new problems or situations. This handling sometimes involves rearrangement and manipulation of stored information, in order to fit in with new perceptual input.

1.7. Approaches to Cognitive Psychology

There are four main approaches to cognitive psychology, each of which has made a valuable contribution to this field of study: experimental cognitive psychology, cognitive science, cognitive neuropsychology, and cognitive neuroscience. These branches are succinctly introduced below.



- a- **Experimental Cognitive Psychology**: an approach to understanding human cognition through empirical research on normal human subjects. This approach presumes that cognitive processes can be tested using empirical methods because they can be inferred from behaviour obtained under controlled conditions.
- b- **Cognitive Science**: an approach to develop computational models to further our understanding of human cognition. This involves writing programs to stimulate certain aspects of human cognitive function, in order to test out possible models of brain functions. It studies the mind.
- c- **Cognitive Neuropsychology**: an approach to investigate brain-damaged patients as a way to understand normal human cognition. Are there any specific cognitive impairments brought about by damage to a particular brain region? If so, it's likely that the damaged area is involved in that cognitive function.
- d- **Cognitive Neuroscience**: an approach to studying brain-damaged patients but with a particular focus on uncovering the neural mechanisms underlying cognitive processes. It involves using brain-imaging devices such as fMRI (functional magnetic resonance imaging) to discover where these processes occur in the brain, and when (including for instance, the order that different areas are activated when a person attempts a task).

These four approaches to the information-processing activities of the brain began as separate disciplines, but in recent years they have begun to merge as their overlapping generated a new level of understanding.

1.8. Methods of Research in Cognitive Psychology

To understand the specific methods used in cognitive psychology, we must first grasp the goals of research, which may include data gathering, data analysis, theory development, hypothesis formulation and hypothesis testing.

- data gathering: the more cognitive psychologists have data on a cognitive phenomenon, the more they can draw inferences.
- data analysis: this enables researchers to describe and explain a phenomenon, which includes the what, how, and why of thinking.
- theory development: to study a phenomenon, researchers start with a theory, a set of general explanatory principles regarding a phenomenon usually based on observations. If the theory is correct, then when “X” occurs, outcome “Y” should result.
- hypothesis formulation: the process above results in the generation of hypotheses (tentative proposals/solutions).
- hypotheses testing: through experimentations in order to retain or reject a hypothesis. If particular findings appear to confirm a given hypothesis, the findings must be subjected to statistical analysis to determine their statistical significance (the likelihood that a given set of results would be obtained if only chance factors were in operation).

Cognitive psychology is a **scientific** study, which means that we need to test a hypothesis to examine variables that influence behaviour. Hypothesis states that two variables are related in some way and altering one of them may cause the participant to alter the other.

There are **two** types of **variables** that should be included in each hypothesis: an **independent variable** (IV) which the researcher deliberately manipulates; and a **dependent variable** (DV) which shows the results of change (DV measures any changes IV has produced). So, the IV is altered to see the effect it has on the DV. This means that cause and effect are measured.

A hypothesis can be tested using both **experimental** and **non-experimental** methods. In **the experimental methods**, we study the influence of the manipulated IV on the DV. This involves lab experiments and field experiments, computer simulations and artificial intelligence.

- simulation: attempts to make computers simulate (through special programs) human cognitive performance to test out models of possible brain function (e.g., robots).
- artificial intelligence (AI): attempts to make computers demonstrate intelligent cognitive performance, regardless of whether the process resembles human cognitive processing (e.g., playing chess through processes not necessarily used by human experts).

In **non-experimental methods**, we tend to study cognition behaviour in the real world (social context) not in a laboratory so that it does not become unnatural. This involves case studies, observations self-reports (introspection).

- case study: an in-depth study of an individual (the case of the girl “Genie” who was locked in a room for 13 years; information revealed how she later learned language).
- self-report: an individual’s own account of cognitive processes through diaries, surveys (interview/ questionnaire), and verbal protocols (describing aloud one’s thoughts and ideas during the performance of a cognitive task).
- observations: observing subjects in their natural environment (classrooms, workplaces, homes ...)

1.9. Conclusion

Cognitive psychology is a relatively modern approach to human behaviour that focuses on how we think. It assumes that our thought processes affect the way in which we behave. The approach came about in part due to the dissatisfaction with the behavioural approach, which focused on our visible behaviour without understanding the internal processes that create it. The cognitive approach is based on the principle that our behaviour is generated by a series of stimuli and responses to these by thought processes. Cognitive psychologists believe that behaviour can be essentially described in relationships of how the mind functions. This new discipline came out with scientific conclusions that helped researchers understand the nature of human cognition and behaviour.

2. Attention

2.1. Introduction

Ordinarily, we speak of giving attention to objects, concentrating attention on some object or shifting attention from one object to another. This may give the impression that attention is some faculty or power that we can use at will. But it is better to speak of attending, the act, process or function of attending rather than any power.

Psychology studies mental processes and activities but it is difficult to do this without attending to them. Attending to an object is to bring that object to consciousness. To perceive an object—to think about it, to solve some problem about it, to remember it and the like—is not possible without attending to it. By attending to anything, we bring it within the realm of consciousness. Attention is the heart of the conscious process and is basic to all mental activities and behaviours. Attention in a way precedes all mental activities.

2.2. Definitions

As is the case for many concepts in psychology, there is no general consensus among researchers regarding the definition of Attention. However, a very influential definition by William James (1890) remains very reliable. He defines attention as “the taking into possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalisation, concentration of consciousness are of its essence” (pp. 403 – 404).

Simply speaking, attention is the cognitive process of selectively concentrating on one aspect of the external or internal environment while ignoring other aspects.

2.3. Importance of Attention

It is often of great importance to the individual whether he attends to an object carefully or not. Accidents are the result of the failure or lack of careful attention to small details.

a- attention improves sensory discrimination: we are exposed to a large number of stimuli but attention separates its object from the rest and enables us to observe it carefully. This focused attention makes fine distinctions in perceiving things which otherwise would have passed unnoticed. Attention makes things clearer and more distinct.

b- attention also directs our energies: we respond to some stimuli and ignore others. To be attentive is to concentrate one’s efforts in a certain direction so that things and ideas we attend to are relevant to our needs and purposes.

c- attention increases efficiency: it helps us get ready to meet any situation. Attention is a preparatory adjustment and inattentive people are seldom efficient and successful.

d- attention helps us remember experiences more accurately and fully: those things to which we attend very carefully are recalled with vividness and in detail.

2.4. Attention as a Cognitive Process

Attention is a basic component of our biology, present even at birth. Our orienting reflexes help us determine which events in our environment need to be attended to, a process that aids in our ability to survive. Newborns attend to environmental stimuli such as loud noises. A touch against the cheek triggers the rooting reflex, causing the infant to turn his or her head to a nurse and receive nourishment.

These orienting reflexes continue to benefit us throughout life. The honk of a horn might alert us about an oncoming car. The blaring noise of a smoke alarm might warn you that the casserole you put in the oven is burning. All of these stimuli grab our attention and inspire us to respond to our environment.

2.5. Characteristics of Attention

Attention is/does:

- a. mental process
- b. selective process
- c. motivational process
- d. always shifting
- e. purposive
- f. dynamic / exploratory
- i. adjustive in nature (for body and tension reduction)
- g. increases the clearness of the stimuli (figure and background)
- h. goes before perception and reaction

2.6.Types of Attention

There are four major types of attention: sustained, selective, alternating, and divided.

a- Sustained attention

Sustained attention is the ability to focus on one specific task for a continuous amount of time without being distracted. Sustained attention is probably what you think of when you hear the words "attention", "focus", "concentration", or "vigilance." You use sustained attention when you continuously maintain focus on one task or concentrate on an activity for a prolonged period of time without getting distracted. Examples of sustained attention may include listening to a lecture, reading a book, playing a video, or fixing a car.

It can be challenging to maintain this type of attention for a significant amount of time without becoming distracted. Therefore, your level of sustained attention will often vary. You may be intensely focused for one minute and then your attention may begin to lapse. However, a key aspect of sustained attention is the ability to re-focus on the task after a distraction arises.

b- Selective attention

Selective attention is the ability to select from the various factors or stimuli that are present and to focus on only the one that you want. Every day, you are constantly exposed to a number of environmental factors or stimuli, but your brain naturally responds by selecting a particular aspect or

factor to focus on. Selective attention basically allows you to be able to “select” what you want to pay attention to. You may need to use selective attention when attending a loud party and you are focusing on one person’s voice, or if you are trying to study in a noisy room.

When employing selective attention, you are able to avoid distractions from both external (e.g., noise) and internal (e.g., thoughts) influences. If you are good at selective attention, you are good at ignoring distractions and able to maintain a specified level of performance in the presence of distracting stimuli.

c- Alternating attention

Alternating attention is the ability of mental flexibility that allows you to shift your focus of attention and move between tasks having different cognitive requirements. It is alternating your attention back and forth between two different tasks that require the use of different areas in your brain. You probably use alternating attention almost all the time. You constantly need to make sudden changes in your activities or actions which require your attention to shift. You may use alternating attention when reading a recipe (learning) and then performing the tasks of the recipe (doing). It could also be alternating between unrelated tasks such as cooking while helping your child with her homework.

d- Divided attention

Divided attention is the ability to process two or more responses or react to two or more different demands simultaneously. Basically, it involves dividing your attention between two or more tasks. It is often referred to as multi-tasking. Examples of divided attention include checking email while listening in a meeting, talking with friends while making dinner, or talking on the phone while getting dressed. Unlike alternating attention, divided attention involves splitting your attention and focusing part of it on each of the two or more tasks you are performing.

Many researchers argue that it is humanly impossible to concentrate on two different tasks simultaneously. Your brain can only process one task at a time. So, you are really not “focused” on two tasks at a time, but continuously alternating your attention between them. That is why, according to them, it is so difficult and dangerous to text and drive or talk and drive.

Some studies claim that you are able to use divided attention successfully because of *muscle memory* and/or *habit*, which allow you to perform two or more tasks seemingly simultaneously such as reading music and playing an instrument or driving your car while listening to the radio.

Other studies have revealed that if one of the two tasks is of an *autonomic* nature, it is possible to attend both tasks simultaneously with almost equal efficiency. Autonomic tasks generally require no conscious effort to attend. Therefore, only one of the tasks generally requires conscious effort to attend. For example, a student can simultaneously read and listen to the radio; a typist can work on his machine and also talk to someone. In such cases, one of the tasks becomes so autonomic that it requires attention only in intervals, and therefore, all attention can be directed to another task. However, when both tasks require conscious efforts to attend, attention is divided between them and the tasks cannot be performed so efficiently as those which are given attention separately. Thus, attention has the attribute of being divided when two stimuli simultaneously require focus.

2.7. Factors that Affect Attention

Why do people attend to some objects and ignore others? To answer this question psychologists have laid down some conditions or factors. Broadly, there are (a) internal factors, and (b) external factors which determine what object will attract or compel attention. Some psychologists call them *determinants* of attention and classify them as ‘subjective’ (internal) and ‘objective’ (external).

a- Internal factors (subjective determinants) of attention

It is a common experience that you attend to an object and ignore another. This is because of subjective or personal factors which include the following:

aim/ purpose	attitudes	basic needs (food deprivation)
curiosity	emotion	education and training
habit or practice	mood	desire and interest
mental set	training	meaning and understanding
past experiences	social motives	temperament (religious, musical, cool nature, etc.)

b- External factors (objective determinants) of attention

Objective determinants of attention are concerned with the environmental factors, which include the object and its qualities and intensities.

- ✓ nature of stimulus: all related to the sense organs
- ✓ intensity of the stimulus: bright colours attract attention more (e.g., in packaging...)
- ✓ size of the stimulus: more than average is more attentive (someone’s big head...)
- ✓ position of the stimulus: eye-level position (figure, background, covers of a magazine...)
- ✓ repetition of the stimulus: repeated stimulus grabs attention (advertisement ...)
- ✓ change of the stimulus: a sudden change in the stimulus (sound...)
- ✓ novelty of the stimulus: unexpected stimulus in the environment attracts attention
- ✓ contrast of the stimulus: female among the male
- ✓ movement of the stimulus: stimulus in motion catches greater attention
- ✓ rareness of the stimulus: unusual stimulus in the environment attracts attention
- ✓ strangeness or secrecy of the stimulus: secret news triggers attention
- ✓ duration of the stimulus: the longer the presence, the bigger the influence on the sense organs (advertisement...)

2.8. Span of Attention

Of all the stimuli around us, we attend to only a few. Attention divides our field of conscious experience into focus and margin. The objects, things or events that exist in the focus stand out as distinct and clear. Rest is in the margin and we are either unaware of them, or if at all, give them a very dim (light, weak) and ambiguous apprehension.

What number or amount of objects can simultaneously exist in the focus? This question has been subjected to experimental investigation. **The general opinion is that in a single act of attention, one can attend to only one object.** However, this statement needs to be further analysed. Objects may be simple or complex. For example, you observe a house as a single unit or object. But this house

is a composite of several objects—windows, doors, number of floors, etc.—each one is a unit in itself. Therefore, the singleness of the object varies according to the purpose at hand.

Experiments show that the number of objects one can hold in his focus of attention is usually limited. This is referred to as the **span of attention**, that is, **the number of stimuli attended to in a single act of attention**. The span of attention is the number of objects that stand out distinctively clear in one single moment of observation.

2.9. Fluctuation of Attention

Fluctuation of attention is the **length of time** one can attend continuously to a single object. Attention is not steady or concentrated throughout. At one time, the object comes into our focus, at another time, it goes out of focus. Closely related to fluctuation is **the shift** of attention. In the shift of attention, our attention **passes from one stimulus to another** or from one part of a complex stimulus to another part.

Attention is a mobile or dynamic activity, and it is difficult to attend to one particular object for any great length of time. **When attention moves from one object to another, it is called the shifting of attention**. But even **when attention persists with one object, it grows more or less in degree**. **This is called fluctuation of attention**.

The **cause** of fluctuation in attention is attributed to the temporary **slackness in the mental activities and sense organs**. Some psychologists found that fluctuation occurs even when the muscles are numbed (lacking feeling or responsiveness). Fluctuation is then believed to be due to the changes in adjustment or adaptation. Though nothing can be said definitely about this matter, still, the importance of the sense, mind, psychological state and environmental factors in the fluctuation of attention are undeniable.

2.10. Attention and Learning

Learning is the process of memorisation, integration and application of new information and concepts. The first step in learning anything is 'paying attention' to it. Thus, without an adequate cognitive focus on the task at hand, it is impossible for information to register in working memory and to be actively processed. This is why poor attention to the task is considered one serious potential cause of learning problems. Attention is either attracted by some external stimulus or is guided by personal goals. Factors influencing a learner's attention include the novelty, intensity, interest and importance of the stimulus or task, the perceived value and difficulty level of the task, the learner's physical and emotional state, and the learner's ability to ignore distractions. Swanson and Saez (2003) refer to the capacity to maintain attention in the face of interference or distraction as 'controlled attention'. Controlled attention is governed by executive cognitive processes and requires some degree of metacognition and self-regulation. Students with learning difficulties are found frequently to be weak in controlled attention.

Some students with poor attending behaviour have a specific 'attention deficit disorder', with or without hyperactivity (ADD and ADHD). Children with **ADHD** exhibit symptoms of **impulsivity**, **distractibility** and **hyperactivity** in addition to **attentional problems**. They also have serious problems with schoolwork, difficulties in social interaction with peers, and may have language

disorders. Typically, children with ADD and ADHD suffer from severe difficulties in the following areas:

- getting started on tasks
- staying on task
- changing easily from one activity to another
- completing a task
- following directions
- self-management.

Definitive causes of ADD and ADHD have not been found, but many possible causal factors have been suggested, ranging from inner ear problems, prenatal and postnatal abnormalities, inappropriate diet, genetic predisposition, and low levels of certain neurotransmitters in the brain.

Teachers can play a decisive role in helping learners maintain attention. Hunt and Marshall (2002) discuss the importance of all teachers using **strategies that will grab and maintain students' selective attention**. These strategies include the use of **attentional cues, metacognitive training and self-monitoring**. Teachers are also encouraged to **build on learners' prior knowledge and experience**, because it may have an effect on attention to new information (Dockrell & McShane, 1992). If learners are already familiar with most aspects of a stimulus or task, they may know immediately which salient features to attend to. Research has also shown that students' selective and sustained attention to a task will improve as they experience greater success in performing the task. To this extent, success and failure also influence future attending behaviours.

2.11. Conclusion

Attention is a term commonly used in education, psychiatry and psychology to refer to our ability to focus and maintain interest in a given task or idea, including managing distractions. Psychologists consider it a core cognitive process because it is the basis on which other cognitive processes can be studied; most importantly learning.

3. Perception

3.1. Introduction

Perception is one of the most important concepts in cognitive psychology which received much attention from psychologists and researchers. In fact, it is a major cognitive process which enables individuals to make sense of the surrounding world and interact with it. We are daily exposed to thousands of environmental stimuli captured by our senses, however, only some of them are processed in our brains through a complex cognitive procedure necessary for constructing mental representations which constitute our individual experiences. These experiences are stored in memory and used by individuals to interact with the external environment–behaviour. Perception is also a vital component of the information processing system together with sensation and attention.

3.2. Definition

As is the case for many psychological concepts, there is no common consensus among psychologists on a single definition of perception. In fact, many definitions were put forward. For instance, Groome (1999) states that “perception is the process by which we make sense of our surroundings by interpreting the information from our sense organs” (p. 13). According to Pike and Edgar (2005), perception is the process of constructing a description of the surrounding world. Epstein and Rogers (1995) claim that perception is the set of processes by which we recognise, organise, and make sense of the sensations we receive from environmental stimuli.

Simply put, perception refers to the occurrence when the brain organises information it obtains from the sensory organs, and then begins the process of translation and interpretation. It is a vital process that helps us make sense of the information related to the physical stimulus.

3.3. Perception vs. Sensation

In everyday language, many people use the terms **sensation** and **perception** interchangeably thinking they refer to the same thing. However, they are very distinct, yet complementary processes. We have already learnt what perception is and what it entails. Let’s now go through sensation.

Groome (1999) defines sensation as “the intake of information by the sense organs” (p. 13). According to Pike and Edgar (2005), sensation is the ability of our sense organs to detect various forms of energy (such as light or sound waves). Sensory organs absorb energy from a physical stimulus in the environment, and then, sensory receptors convert this **physical energy** into **neural impulses (electrical energy or signals** that the brain can understand) through a process called **transduction** and send them to the brain. In the brain, the neural impulses (signals) go through a series of organisation, translation and interpretation–perception. That is, when the brain receives these signals, it converts them into feelings (touch or pain), taste, sound, sight, and odour. Once perception is finished, a person is able to “make sense” out of the sensations. For instance, seeing the light (sensation) is different from determining its colour (perception); hearing a sound is different from perceiving the music being played. Perception progresses from sensation to the higher-level cognitive processes that are performed on that information. So, perception is almost like a **sixth sense**. It is what we perceive or form an opinion on of anything and everything happening around us.

Sensation and perception are elements that balance and complement one another. They work together for us to be able to identify and create meaning from stimuli-related information. Without sensation, perception will not be possible, and without perception, our sensations would remain "unknown" to us since there is no mental processing of what we sense.

On the other hand, perception and sensation are different mostly because sensation is more physical, whereas, perception is more of a psychological concept. In other words, sensations arise only because the body receives a stimulus and reacts to it, converting this stimulus into one of the things that one of the sensory organs of the body can identify. However, perception is absolutely psychological as it represents individual thoughts of individual people—personal experience. It is what a person thinks about his or her environment, and it is how the person looks at the world around him or her.

In sum, sensation can be referred to as the **passive** process of bringing information from the outside world into the brain as a result of external stimulations received by the five sensory organs of the body: ears, eyes, nose, tongue, and skin. The process is **passive** in the sense that **we do not have to be consciously engaging in a "sensing" process**. Perception can be viewed as the **active** process of **selecting, organising, and interpreting** the information brought to the brain by the senses. It is the mental image of something or somebody made due to the different actions exhibited by the environment around us.

3.4. Types of Perception

Perception is a complex process that allows us to connect with the surrounding world. Classically, perception is divided into five senses:

a- Visual (sight) perception: the ability to see and interpret light information within the visible spectrum that arrives to our eyes. The area of the brain responsible for visual perception is the **occipital lobe**.

b- Auditory (hearing) perception: the ability to receive and interpret information that arrives to our ears by audible frequency waves through the air or another mean (sound). The brain part in charge of the basic stage of auditory perception is the **temporal lobe**.

c- Haptic (touch) perception: the capacity to interpret information of pressure and vibration received on the surface of our skin. The **parietal lobe** is the part of the brain responsible for the basic stages of haptic perception.

d- Olfactory (smell) perception: the ability to interpret information about chemical substances dissolved in the air (smell). The basic stages of olfactory perception are done by the **olfactory bulb** (primary olfactory cortex) and the **piriform cortex** (secondary olfactory cortex).

e- Gustatory (taste) perception: the ability to interpret information from chemical substances dissolved in saliva (taste). The main brain areas in control of the basic stages are the primary **taste areas G1** (postcentral inferior gyrus, parietal ventral lobe, anterior insula, fronto-parietal medial operculum) and **secondary taste areas G2** (caudolateral frontal orbital cortex and anterior cingulate cortex).

3.5. Phases of Perception

Perception is **not a single process** that happens spontaneously. Instead, it is a **series of phases** that take place in order for the correct perception of stimuli to occur. For example, to perceive **visual information**, it is not enough for light to reflect off an object, stimulating our retinal receptor cells for them to send this information to the correct brain areas. For perception to happen, all of that is necessary. However, perception is an **active process**, where we have to **select, organise** and **interpret** the information sent to the brain:

a-Selection: the number of stimuli we are exposed to daily exceeds our capacity. For this reason, we need to **filter and choose** the information we want to perceive. This selection is done through our **attention** which reflects our experiences, necessities and preferences.

b-Organization: once we know what to perceive, we need to **gather** the stimuli in **groups** in order to give them meaning. In perception, there is **synergy**, since it is an overall perception of what is perceived and it cannot be reduced to separate stimuli characteristics. The process of stimuli organisation is not random but instead, it follows specific criteria.

c-Interpretation: when we have organised all the selected stimuli, we then proceed to **give them meaning**, in order to complete the perception process. The interpretation process is **modulated** by our experience and expectations.

3.6. Types of Perceptual Processing

Cognitive psychologists have come to distinguish between two main types of input processing known as **top-down** processing and **bottom-up** processing. **Top-down processing**, also referred to as schema-driven or concept-driven processing, is processing which makes use of stored knowledge (schemas) and prior expectations in order to guide the interpretation of sensory stimulus. That is, the flow of information progresses from the top down as it starts with existing knowledge stored in the brain, and then is sent down the nervous system for comparison with the incoming stimulus. Top-down processing is a high-level cognitive process, which states that perception is constructed by cognition (our behaviour is influenced by conceptual data housed within our higher-order cognitive processes that construct our experiences and expectations).

Bottom-up processing, also referred to as stimulus-driven or data-driven processing, is processing based on the applications of processing rules to the data present within the stimulus in a way that does not depend upon such previous experience. It is called so because it is initiated by stimulation at the ‘bottom end’ of the nervous system (i.e., the sense organs) which then progresses up towards the higher cortical areas in the brain. This means that the flow of information through the perceptual system starts from the bottom—the sensory receptors—and works upward until an internal representation of the object is formed. Bottom-up processing is a low-level cognitive process which posits that perception directs cognition or behaviour (environmental data is used by the brain’s cognitive processes to do things like making decisions or determining behaviour).

3.7. Factors that Affect Perception

A number of factors operate to **shape** or sometimes **distort** our perception of reality or understanding of the environment (sensory impressions). These factors can reside in the **perceiver**, the **target** being perceived and the **situation** in which perception takes place.

- **The perceiver:** this refers to a person whose awareness is focused on the stimulus, and thus begins to perceive it. In this case, **perception (interpretation) is influenced by the personal characteristics of the perceiver per se**. These characteristics may include, among many others, motivation, emotion, attitude, interest, past experience and expectations. All of these factors greatly contribute to how the person perceives a situation or an object. For example, if we expect police officers to be authoritarian or doctors to be unscrupulous, we may perceive them as such regardless of their cultural traits.

- **The target:** this includes the object of perception—something or someone being perceived. It refers to the amount of influence **the characteristics of the target and its relationship to its background (context) have on perception**. For example, loud people are more likely to be noticed in a group than quiet ones. As targets are not looked at in isolation, the **relationship** of a target to its **background** also influences perception. For instance, we always tend to group close and similar things together.

- **The situation:** the **context** in which we see objects and events is also important. So, timing, location, light, heat, cold, noise, degree of stimulation and other **environmental factors** also affect the process of attention, and therefore, perception. For example, a teacher in sportswear on a playing field may not grab students' attention; however, if he attends the class in the same clothes, he would be the focus of the audience. Neither the target (teacher) nor the perceiver (students) changed between the playing field and the class, but the situation is different.

3.8. Conclusion

Perception is our sensory experience of the world around us and involves both recognising environmental stimuli and actions in response to these stimuli. Through the perceptual process, we gain information about properties and elements of the environment that are critical to our survival. Perception not only creates our experience of the world around us; it allows us to act within our environment. Perception is the gate to knowledge and understanding of the reality lying beyond objects and events.

4. Information Processing Approach (IPA)

4.1. Introduction

Information Processing is an approach to the study of human cognition, that is, how the human brain receives, stores, integrates, retrieves, and uses information (cognitive processes or functions). This approach is based on the premise that humans process the information they receive, rather than merely responding to stimuli (as posited by behaviourism). It equates the mind to a computer, which is responsible for analysing information from the environment. This theory addresses how children grow, their brains likewise mature, leading to advances in their ability to process and respond to the information they receive through their senses.

Information Processing Approach is based on a number of assumptions, including:

- (1) information made available by the environment is processed by a series of processing systems (e.g., attention, perception, short-term memory);
- (2) these processing systems transform or alter the information in systematic ways;
- (3) the aim of research is to specify the processes and structures that underlie cognitive performance;
- (4) information processing in humans resembles that in computers.

4.2. Brief Historical Background

IPA evolved out of the American experimental tradition in psychology in the 1950s as an alternative to the behavioural approaches that were popular at that time. Behaviourism denied any internal cognitive processes of the human brain and, merely relied on explaining human behaviour, including learning, as natural responses to external stimuli.

The cognitive revolution of the mid-20th century, which coincided with the advent of the computer, reacted against behaviourist claims and asserted that there existed meditational processes between stimulus and response that should be studied and described in terms of rules.

A primary focus of IPA is on memory (the storage and retrieval of information). The most widely accepted theory in this respect is based on the work of Atkinson and Shiffrin (1968), which will be extensively discussed below.

4.3. Brain and Computer Analogy

Information processing theorists propose that like a computer, a human brain is a system that processes information through the application of logical rules and strategies. That is, the human brain **encodes** input, **operates** on that information, **stores** and **retrieves** it from memory, and **produces** output in terms of actions. This brain also has a limited capacity for the amount and nature of the information it can process (STM).

In addition, and just as the computer can be made into a better information processor by changing its hardware and its software (programming), so do children who become more

sophisticated thinkers through changes in their brains and sensory systems (hardware) and in minds—the rules and strategies (software) that they learn. The table below draws a comparative picture between the human brain and the computer.

	Input device	Processing device	Storage device	Output device
Computer	keyboard scanner, mouse	CPU (central processing unit)	hard disk	screen printer
Human brain	sensory organs: eye, ear, hand...	short-term memory	long-term memory	behaviour or action

4.4. Multi-Store Model

One of the most influential models for **processing information** is that proposed by Atkinson and Shiffrin in 1968. This model posited **three memory stores** (stages or centres) for the human memory where information is processed: sensory memory, short-term memory, and long-term memory. Information is thought to be processed in a serial, discontinuous manner as it moves from one stage to the next. It is also called the **Multi-Memory Model** and the **Modal Model**. This model is portrayed in the figure below.

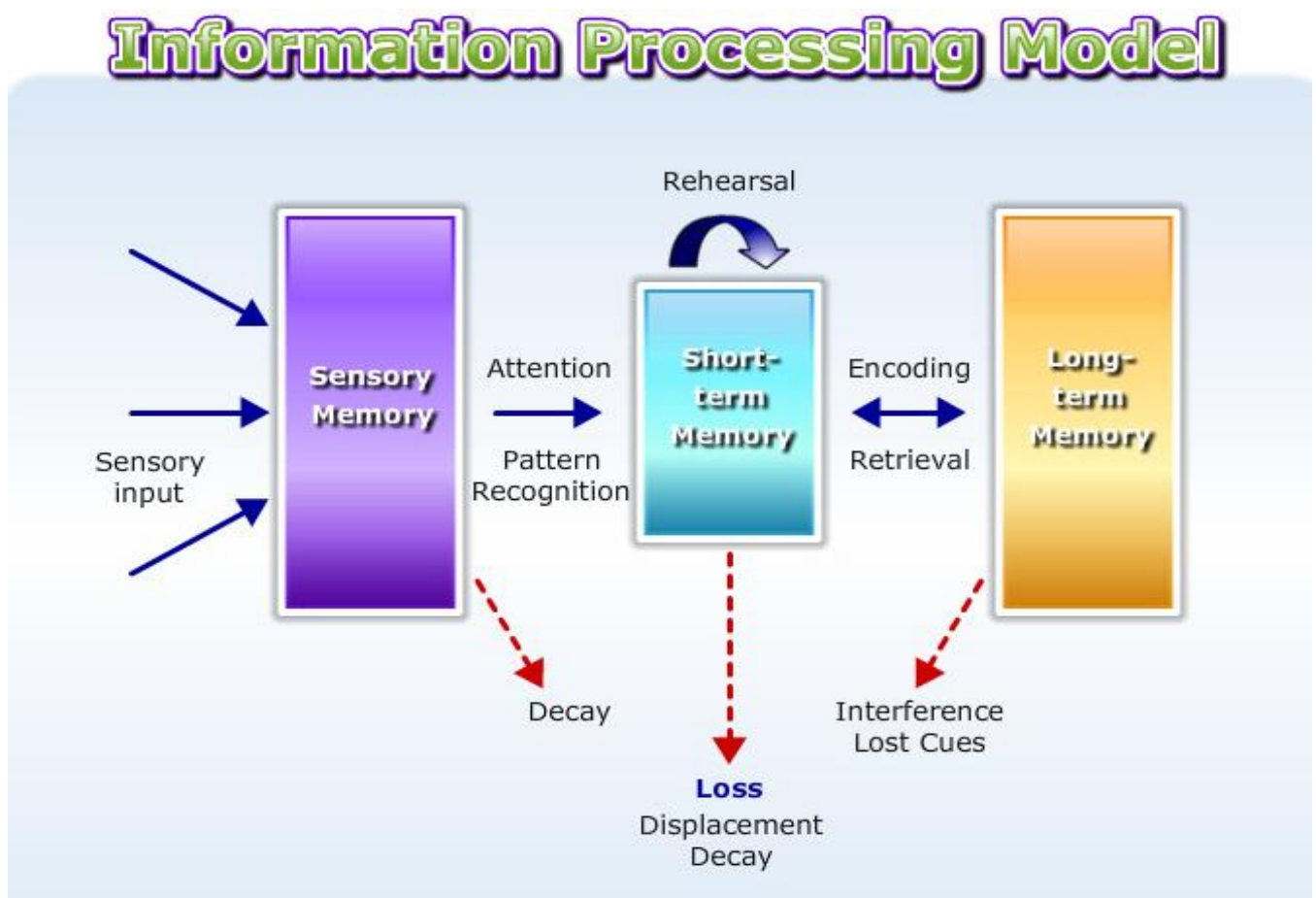


Figure. Atkinson and Shiffrin's 1968 Multi-Memory Model.

4.4.1. Definition of Memory

Before we explain in detail the three stages of memory, it is quite appropriate to **define** memory and identify the major **cognitive processes** which characterise it. According to Santrock (2011) “memory is the retention of information over time” (p. 263). Sternberg (1999) claims that memory is how we draw on our past experiences in order to use this information in the present. Without memory, we would not be able to connect what happened to us yesterday with what is going on in our lives at present. Psychologists emphasise that it is important to view memory not in terms of how we add something to it, but rather how we actively construct it.

4.4.2. Three Major Memory Processes (encoding, storage, retrieving)

Psychologists also admit that **three major cognitive processes** characterise human memory: how information is initially placed or **encoded** into memory, how it is retained or **stored** after being encoded, and how it is found or **retrieved** for a certain purpose later. These processes will be extensively discussed later in separate lectures. Now, let’s go back to the stages of memory as proposed by Atkinson and Shiffrin.

The **multi-store model** is a very common model of memory assuming that there are different types of memory used for different tasks. It is an explanation of how memory processes work. We hear, see and feel many things, but we can only remember a few. These stores link together in an effective sequence as explained below.

4.4.3. Sensory Memory

The first stage is sensory memory (registry), which contains **receptors** that briefly hold on to only that information that enters through our **senses**. Sensory memory is a temporary storage centre that receives and holds sensory input for one or two seconds before beginning to encode the information for further processing. Information that you do not attend to or that you ignore fades or becomes discarded quickly. This function of the sensory memory for holding sensory input for only one or two seconds works as a filter for the rest of your memory system because our memory system would overload if we attempted to use mental activity to process every piece of sensory information we receive. Sensory memory is affiliated with the **transduction** of energy (change from physical form of energy to neural impulses—electrical energy). The environment makes a variety of sources of information (light, sound, smell, heat, cold, etc.) available, but the brain only understands **electrical energy**. The body has special sensory receptor cells that transfer this external energy to something the brain can understand (electrical energy). In the process of transduction, **a memory is created**. Two major senses provide us with most of the information we receive from the environment: the **eye** which forms the **iconic memory**, and the **ear** which forms the **echoic memory**.

4.4.3.1. Iconic Memory

The visual system possesses **iconic memory** for visual stimuli such as shape, size, colour and location (but not semantic meaning). It is very limited in capacity and lasts for **half a second** (rapid decay).

4.4.3.2. Echoic Memory

The hearing system has **echoic memory** for auditory stimuli (sound and its aspects such as pitch, rhythm, etc.). It has a bigger capacity than iconic memory and lasts from **3 to 4 seconds**.

It is absolutely critical that the learner **attend to the information** at this initial stage in order to **transfer** it to STM. Two major **concepts** guide this process:

First, individuals are more likely to **pay attention** to a stimulus if it has an **interesting feature**. We are more likely to get an orienting response if this is present.

Second, individuals are more likely to **pay attention** if the stimulus activates a **known pattern**. To the extent we have students call to mind relevant prior learning before we begin our presentations, we can take advantage of this principle.

4.4.4. Short-Term Memory (STM)

The second stage is short-term memory (STM), a **temporary storage facility**. STM relates to what we are **thinking** about at any **given moment** in time. It refers to the memories which we are holding in **conscious awareness**, and which are currently receiving our **attention**. That's why, Taylor (2002) claims that STM defines our immediate consciousness. So, short-term memory is a **conscious** memory created by our paying **attention** to an **external stimulus**, an **internal thought**, or both. It can hold up to 7 ± 2 (from 5 to 9) chunks (items) of information with a duration of about 15 to 30 seconds unless it is **rehearsed** (practised), at which point it may be available for up to 20 minutes, 30 minutes in other studies. For auditory information **rehearsal** occurs through continually **repeating** the items to oneself; for visual information, for instance, through intentionally **holding** a visual image in mind.

Atkinson and Shiffrin asserted that the longer information is retained in short-term memory through the use of rehearsal, the greater its chance of getting it into long-term memory. If too much new information enter short-term memory at one time, short-term memory becomes **overloaded** and some or all of the information is discarded. A vivid example of overloading memory is students' cramming for tests or reading complex textbooks quickly.

In most models of memory, short-term memory is represented as a necessary **first step toward long-term storage**; but a vast amount of information that enter short-term memory does not need to be transferred to long-term storage and are very rapidly forgotten. It must be noted that short-term memory **can be impaired (weakened) by anxiety and stress**, and either facilitated or disrupted by certain drugs. According to the Modal Model, **two** major **components** are related to STM: phonological loop and visuo-spatial sketchpad.

4.4.4.1. Phonological loop

The phonological loop is specialised to briefly store **speech-based information** (verbal) about the sounds of language, words, numbers, etc.

4.4.4.2. Visuospatial Sketchpad

The visuospatial sketchpad stores **visual and spatial information**, including visual imagery, maps, etc. These two components have a **limited capacity** and function **independently**. For example, you could rehearse numbers in the phonological loop while making spatial arrangements of letters in the visuo-spatial sketchpad.

4.4.5. Long-Term Memory (LTM)

The third stage is long-term memory (LTM). Long-term memory **refers to the chunks of information which we are not presently holding in conscious awareness** (not thinking about), but which are held in storage ready to be recalled. We become aware of long-term memory only when our STM activates parts of long-term memory to locate previously learned information or to imprint (mark) new information. LTM has unlimited capacity and can retain information for a long period of time in a relatively permanent fashion. Santrock (2007) says that long-term memory means information is retained in the long-term memory over time.

Contemporary psychologists agree that long-term memory can be divided into the subtypes of **declarative** and **non-declarative** memories. Declarative memory is, in turn, subdivided into **episodic** memory and **semantic** memory.

4.4.5.1. Declarative memory

Declarative memory is the conscious recollection of information, such as specific facts or events that can be verbally communicated. It has been called “**knowing that**”, and more recently has been labelled “**explicit memory**.” Demonstrations of a student’s declarative memory could include recounting an event they have witnessed or describing a basic principle of math. It has two types: episodic and semantic.

4.4.5.1.1. Episodic Memory

Episodic memory is the **retention** of information about the **where** (place) and **when** (time) of life’s **happenings** and **events**. A student’s memories of the first day of school are all episodic. Information encoded in our episodic memory is in the form of images. All our past experiences are stored in this memory.

4.4.5.1.2. Semantic Memory

Semantic memory is our memories of **general facts and concepts**, in other words, our general **knowledge**. Most of what we learned in school (mathematical principles, meanings of words, famous people, important places, etc) is stored in our semantic memory in the form of meanings.

4.4.5.2. Non-declarative memory

Non-declarative (procedural) memory is **procedural knowledge** in the form of **skills and cognitive operations**. Non-declarative memory **cannot be consciously recollected**, at least not in the form of specific events or facts. This makes non-declarative memory **difficult, if not impossible, to communicate verbally**. It is sometimes called “**knowing how**,” and recently it also has been

described as “**implicit memory.**” When a child applies his abilities to ride a bicycle, his procedural memory is at work.

4.5. Conclusion

The Information Processing Model is a cognitive model that consists of three memory stores: sensory memory, short-term memory, and long-term memory. It provides a foundation for understanding the kinds of mental activities and connections that are necessary for learning to take place. This model is the result of extensive research and learning theories that explain how sensory stimuli from the physical world move back and forth through the three memory systems when information is processed. Students are supposed to study this approach and try to understand its basics because it equips them with essential knowledge about how the human mind processes information, how memory works, and how they can use this information to increase their learning potential and to tailor or personalise their approach to learning different kinds of information.

5. Encoding and Storage

5.1. Introduction

Memory may be regarded as involving three logical stages, **encoding**, **storage** and **retrieval** (getting information in, keeping it there and then getting it back out). These stages constitute the three major cognitive processes deeply studied by psychologists within information information-processing approach to human cognition. In this lecture, we will deal with the first two processes, namely, encoding and storage. Retrieval will be extensively discussed in another lecture.

5.2. Encoding

Encoding is the crucial first step to creating a new memory. It allows the perceived item of interest to be converted into a construct that can be stored in the brain and then recalled later from short-term or long-term memory. Unless information is encoded, it will not be successfully remembered later. However, just because information is encoded there is no guarantee that it will be remembered later.

5.2.1. Definition of Encoding

Wong (2009) defines encoding as “the **process of attaching codes to stimuli** so your long-term memory can accept, understand, use, and **store** the sensory information. Encoding translates the stimuli into meaningful forms for long-term memory” (p. 39). Rutherford (as cited in Braisby & Gellatly, 2005) claims that encoding is “the label given to the way in which objects and events in the world come to be represented in memory” (p. 270). According to Sternberg and Sternberg (2012), encoding is the process of converting a physical, sensory input into a representation that can be stored in memory. So, encoding is the process by which information is passed on to LTM in the form of mental representations or pictures for storage and effective future retrieval.

5.2.2. Two Ways of Encoding

Simply receiving sensory input is not sufficient to encode information. You must attend to and process that input. Encoding information occurs in two ways: **automatic** encoding and **effortful** encoding.

Automatic encoding (processing) occurs without any conscious awareness. It occurs effortlessly, automatically, without you having to think about it. Examples include details like time, space, frequency, personal experience, and learning some motor skills.

You are always encoding the events of your life. Every day you encode events and can remember what happened, at least for a while. For example, you probably can remember what you had for dinner last night, even though you did not intentionally try to remember that information.

Effortful encoding (processing) occurs when you consciously try to remember information. It requires special attention, thought, and practice. In other words, you have to put in effort to get the information into memory. For example, you would need to pay attention if someone gave you their telephone number or gave you a list of items to pick up at the store.

5.2.3. Types of Encoding

When environmental information comes into your sensory memory, it needs to be changed into a form that can be stored. There are three main ways in which information can be encoded/changed: acoustic, visual, and semantic.

5.2.3.1. Visual Encoding

Visual encoding—also called **imaginal** encoding—is the process of encoding **images** and **visual** sensory information. This means converting new information into mental representations. Visual sensory information is temporarily stored within the **iconic memory** before being encoded into long-term storage by means of the **visuo-spatial sketchpad**. For example, if you try to remember the following list of words, which words do you think you will remember easier?

apple hope house respect cup value

You would probably find it easier to remember the words apple, house, and cup. This is because you can recall the mental images more easily than the words themselves. When you read the word apple, you probably pictured an apple in your mind. Visually encoded information is forgotten easily, therefore, it is the **shallowest** type of processing.

5.2.3.2. Acoustic Encoding

Acoustic encoding—also called **auditory** or **linguistic** encoding—is the processing and encoding of **sound**, **words** and other **auditory input** for storage and later retrieval. This is aided by the concept of the **phonological loop**, which allows input within our **echoic memory** to be sub-vocally **rehearsed** in order to facilitate remembering. You may use acoustic encoding by putting a sound to words or creating a song or rhythm. Learning the alphabet or multiplication tables can be an example of acoustic encoding. If you say something out loud or read aloud, you are using acoustic encoding. It is deeper than visual encoding, but not as deep as semantic encoding. It is **intermediate** processing.

5.2.3.3. Semantic Encoding

Semantic encoding—also called **conceptual** or **abstract** encoding—is the process of encoding **sensory** input that has a particular **meaning** or can be applied to a particular **context**. That is, processing a piece of information based on its **meaning**. Semantic encoding requires linking **new** information to **existing** knowledge to make the new information more **meaningful**. Information that is encoded semantically is better remembered than those encoded visually or acoustically because semantic encoding involves a **deeper** level of processing than visual or acoustic encoding. **Chunking** and **mnemonics** are two main strategies for encoding information semantically.

These three types can be put in the following table for better memorising:

Encoding Type	Processing Level	Definition	Example
Visual encoding	Shallow	Remembering the way something looks	If words stood out in a different colour or size
Acoustic encoding	Intermediate	Remembering the way something sounds	Catchy Commercial Slogan
Semantic encoding	Deep	Remembering something by its meaning	Soccer is a sport ⚽

5.3. Storage

Storage is a vital memory process which relates to where the information is stored, how long the memory lasts (duration), how much can be stored at any time (capacity) and what kind of information is held.

5.3.1. Definition of Storage

Storage is viewed as the placement of new information into memory, or the ability of the mind to store and recall information that was previously acquired.

There are many strategies which can help students retain information in their memory for a longer time, so, they must learn these strategies as they play a key role in **learning**, which cannot be separated from **memory**. Many research studies suggest that there is no such thing as a ‘good’ or ‘bad’ memory but rather that an individual’s memory is either ‘trained’ or ‘untrained’ in its ability to store, organise and access information (Henderson, 1999). Teachers can and should make their students aware of these strategies, which we explain below.

5.3.2. Retaining Information in STM

The main **role** of the STM is to **process information** received from the sensory memory, however, it is also a **temporary storage unit** which holds information for up to 30 seconds while processing. This short span of time can be extended to about 30 minutes thanks to **rehearsal** and **chunking**.

5.3.2.1. Rehearsal

Rehearsal has two types: maintenance rehearsal and elaborative rehearsal. The latter is meant for LTM and will be explained shortly afterwards. As for **maintenance rehearsal**, it is a sort of **rote repetition of the information** in STM. That is, the input is merely repeated in the phonological loop **without further processing**. For example, repeating a phone number or the name of a person a few dozen times.

5.3.2.2. Chunking

Chunking is the process of **grouping** the information we are getting into **meaningful units** or **categories** in a way that facilitates learning (encoding and storing).

Example: 568952487125 $\Rightarrow$ 568 952 478 125

5.3.3. Retaining Information in LTM

Three major conditions lead to the effective retention of information in LTM: elaboration, organisation, and context.

- **organisation:** material that is well organised is easier to learn and to remember than separate bits of information,
- **elaboration:** adding and extending meaning by connecting new information to existing knowledge,
- **context:** aspects of physical and emotional context (places, rooms, what we feel at a particular moment, who is with us) are learned along with other information.

5.3.3.1. Strategies for Retaining Information in LTM

Strategies for retaining information in LTM may rely on the learner him/herself or can be driven by teachers. Below is a description of both categories.

5.3.3.1.1. Teacher-Dependent Strategies

Teachers can help students store information in long-term memory using specific instructional strategies, positive transfer, and dual coding theory.

- **instructional strategies:** teachers may use instructional strategies that actively involve students in learning such as group discussion, singing and reading aloud, cooperative learning, inquiry, discovery, experimenting or learning by doing.
- **positive transfer:** refers to the facilitation, in learning or performance, of a new task based on what has been learned during a previous one. Teachers may transfer learning using appropriate strategies or activities. Schema theory encourages teachers to activate students' prior knowledge and make a connection with new knowledge to enhance students' learning.
- **dual coding theory:** in dual coding theory, theorists suggest that we remember better when two processes are engaged in learning, such as visual learning and verbal learning. For example, a teacher guiding young children to write the digit "8" may provide verbal instruction as well as visual presentation. He/she may begin with a pencil on the child's paper saying, "Let's start by writing the letter "S" and then curving back to join the open end joining something that looks like two circles touching each other on the side."

5.3.3.1.2. Learner-Dependent strategies

Students can choose from a variety of strategies what goes with their learning styles and abilities. The list is inclusive of elaborative rehearsal, mnemonics, self-referencing, spacing, and many other memory devices.

- **Elaborative rehearsal:** is not based on mere repetition but occurs when the information is expanded, embellished on, and related to other concepts already in LTM.
- **Mnemonics:** mnemonic devices help students link what they are trying to learn to previously existing easy-to-remember meaningful information such as **acronyms**, **imagery**, **pegwords** (linking new information to verbal cues) and the **method of loci** (using locations instead of verbal cues)
 - **acronym:** for example, SMS for short messages service
 - **imagery:** to create a vivid mental picture of what we are trying to learn
 - **pegword:** words rhyming with numbers: one is a gun, two is a shoe, three is a tree...
 - **method of loci:** relate items to be learnt to familiar places in a sort of mental journey.

These mnemonic techniques almost invariably involve some method of adding meaning to items which otherwise contain very little meaning, and their effectiveness provides evidence for the view that people are much better at memorising information which has meaning, and to which they can apply their previous knowledge.

- **Other memory gadgets (devices):** students may use **mind mapping**, **graphic organisers**, **fish-bone diagrams**, **tree diagrams**, etc, to enhance their understanding and good memory.
- **Self-referencing:** thinking of the new information and how it **relates to you personally** as in learning history (imagine yourself talking to an important personality), etc. Another example is **preparing to teach someone** else putting much **effort** and **concentration**, which increases the likelihood of remembering.
- **Spacing:** refers to spreading study sessions over time rather than cramming them all into one massive study session. For example, **five one-hour sessions** instead of studying **five hours in a single session**.

5.4. Conclusion

Encoding and storage are two major memory processes that play a vital role in learning and retrieving previously learned information. For this very reason, students should understand how these cognitive processes function so that they can improve their learning.

6. Retrieval and Forgetting

6.1. Introduction

Retrieval, also known as **remembering**, is a key cognitive process as it enables us to call back information previously encoded and stored in long-term memory to our conscious mind (STM). Without retrieval, all stored information would be useless. However, psychologists distinguish information that is accessible in memory from that which is available. **Accessible** information is the information that we can retrieve from memory; whereas **available** information is the information that is stored in memory, but we cannot gain access to them for many reasons. **Forgetting** is the theory used to account for the inaccessibility of stored memory traces (information). In this lecture, we will extensively discuss these two major issues.

6.2. Retrieval

Retrieval is the label given to the way in which information held in memory is made available for use. Retrieval involves **finding**, **activating** and sometimes further **processing** pertinent to memory **representations**. There are **two** major **forms** of retrieval commonly employed in experiments and everyday life: *recall* and *recognition*.

6.2.1. Recall and Recognition

Recall involves **searching** memory without **cues** because you have to come up with the sought-after item on your own; you need to locate that item within your memory. As a result, recall depends heavily on memory **connections** that support the search as they serve as retrieval **paths**. For this reason, forms of **learning** that promote connections are particularly useful for recall testing. That is, we are more likely able to recall items that during the original learning were associated with other things we already know, or with other aspects of the learning environment itself. Recall involves remembering a fact, an event or an object that is not currently physically present (in the sense of retrieving a representation, mental image or concept), and requires the direct uncovering of information from memory, e.g., remembering the name of a recognised person.

Recognition involves **matching** material to external information (cues). In other words, recognition is the association of an event or physical object with one previously experienced or encountered and involves a process of comparison of information with memory, e.g., recognising a known face. Recognition is a largely unconscious process.

The main difference between them can be clearly determined through recall and recognition tests. In a **free (spontaneous) recall** test we are required to generate test items purely from our memory without any outside help; whereas in a **recognition** original test items are represented at the retrieval stage, and we are merely required to indicate whether or not we recognise them. Between these two extremes lies **cued recall**, where we are given cues (i.e., reminders) of the target items but not the actual items themselves. These three types of tests are used to test **memory performance**.

Within **recall**, people generally tend to **remember** the **first** items in a sequence (list), this pattern of having high probability recall is called the **primacy effect**. People also tend to **remember** the **last** items in a sequence, which is referred to as the **recency effect**. It may be **harder** to **remember** the

items in the **middle**, which have no special name. Hermann Ebbinghaus called this tendency to remember the first and last items in a list the **serial position effect**, and the whole curve (**U-form** in a graph) is called the **serial position curve**.

6.2.2. Encoding Specificity Principle

Research has found that **recognition is much easier than recall**, and yields higher retrieval scores. This is why many theories tried to provide an explanation for the superiority of recognition performance over recall performance. **The Encoding Specificity Principle (ESP)** model of memory assumes that **recognition is superior to recall** because it offers more **feature overlap** between input and output, which is **the extent to which features of the trace stored (input) match those available at retrieval (output)**. Therefore, the chance of retrieving a memory trace depends on the amount of feature overlap (matching) between this memory trace and the retrieval cue available during the process of retrieval (Tulving, 1972).

6.2.3. Generate and Recognise Theory

An alternative approach is the ‘**generate and recognise**’ (**GR**) theory (Kintsch, 1968), which proposes that in a **recall test**, we must first **generate** possible target items (information) spontaneously, then, the generated items are subjected to a **recognition** task to **discriminate** between correct and incorrect items. That is, deciding whether the retrieved information is the one that was searched on the basis of a familiarity judgement. In a **recognition test**, however, there is no need to generate possible test items since the items are already in front of us. Thus, recall is seen as having two stages (i.e., generate and recognise), whilst recognition has only one stage (i.e., recognise). This could explain why recall is more difficult than recognition.

6.2.4. Familiarity and Recollection

Both the GR and ESP theories of retrieval assume that recognition is essentially a single process, but Mandler (1980) suggests that **recognition may involve two alternative retrieval routes**. The first is a **familiarity** rating, which simply involves **making a judgement as to whether or not an item has been encountered before** (judgments of prior occurrence). The second is the **recollection** of actual occasions when the item was encountered. The distinction between these two processes is well illustrated by a phenomenon that all of us have probably experienced at some time, which is the **inability to identify a familiar person seen outside of their normal context**. That is, we establish a person’s familiarity at the first stage, but we can’t recollect the setting from which he is familiar. This may come to you later with a bit of effort, but it requires the recollection of actual occasions when you have previously met the person. **The fact that familiarity can occur without recollection demonstrates that these are two separate retrieval processes**. Familiarity and recollection might therefore operate as two independent retrieval routes, which may be used either separately or in combination. The table below compares these two processes:

Familiarity	automatic	effortless	involuntary	Unconscious
Recollection	controlled	effortful	voluntary	conscious

6.2.5. Context-Dependent Memory

Returning to some **earlier contextual setting** can serve as a powerful **cue** for the retrieval of memories. You may have noticed that when you revisit someplace where you spent part of your earlier life, old memories from that period tend to come flooding back, cued by the sight of a street or a building that you have not seen for many years. Sometimes a particular piece of music may bring back old memories, or even a smell or a taste which you have not experienced since childhood. These are all examples of contextual cueing, and they rely on revisiting or reinstating (restoring) an earlier context. The occurrence of context-dependent memory clearly fits in very well with ESP theory, which predicts that retrieval depends on the amount of feature overlap, including that for contextual information.

6.2.6. State-Dependent and Mood-Dependent Memory

A phenomenon related to context-dependent learning is the finding that retrieval can be assisted by the reinstatement of a particular **mental state** at retrieval which was also present at the learning stage. For example, Bower et al. (1978) found that retrieval of a wordlist was slightly better if the subjects were in the same **depressed mood** at retrieval as they had been in at the learning stage. In this experiment, depressed mood states were induced by the use of *hypnosis* (the induction of a state of consciousness in which a person apparently loses the power of voluntary action and is highly responsive to suggestion or direction). All in all, state of mind and mood are considered two retrieval cues which can assist memory.

6.3. Forgetting

Most studies of forgetting have focused on **declarative** (explicit) memory which involves conscious recollection of previously learned information. It is perfectly **natural** to **forget** information as Westwood (2004) states, because we cannot, and do not need to, remember everything. Forgetting is defined as the **inability** to retrieve information (Baddeley, 1997). Tulving (1983) makes the case that much of our forgetting is due to problems in **accessibility** or the failure to retrieve memories that still reside in long-term memory. This contrasts with forgetting due to problems in **availability**, where the memory is simply no longer stored in the brain. Forgetting can either occur because of problems in **STM** or **LTM**. There are many theories which try to account for the issue of forgetting.

6.3.1. Decay

Decay is a theory of forgetting in STM which states that **over time memory traces simply fade away**. It is **the passive loss of the memory trace due to inactivity or lack of rehearsal**. Actually, this is not a new idea. Thorndike has postulated three major laws of learning and one of them is the law of exercise. In this law, Thorndike stated that the more an S–R connection is used, the stronger it becomes; conversely, the less it is used, the weaker it becomes. Hence, through inactivity, the S–R connection simply weakens over time.

6.3.2. Displacement

Forgetting **occurs** in the **STM** because **old items have been displaced (replaced)** by new pieces of information and therefore the original items are lost. Studies showed that material which is not

rehearsed is forgotten, despite the presentation rate, and that STM has a limited capacity store where new items very quickly displace old ones so that original information is forgotten.

6.3.3. Interference

Interference is a theory of forgetting in LTM which dominated during much of the twentieth century. According to Ebbinghaus (1885, as cited in Tulving, 1983), our **ability to remember what we are currently learning can be disrupted** (interfered with) by **previous learning** (proactive interference) or by **future learning** (retroactive interference). That is, memories are actively disrupted by the influence of some other input. Interference takes place when the recall of one event is inhibited by the incursion of another event. There are two types of interference: **proactive and retroactive**.

- **proactive interference** occurs when old information (A) disrupts your encoding and retrieval (or learning) of new information (B). That is, the tendency for old memories to interfere with the learning of newer memories (proactive interference goes forward). Psychologists theorise that it is difficult to create a new memory that actually contradicts or is too similar to older memories. For example, you could have trouble learning a new math concept because it conflicts with preconceived notions or assumptions you may have regarding a similar topic, or, you may have difficulties with foreign currency when travelling abroad.
- **retroactive interference** occurs when the learning of new information (B) prevents the recall of the older information (A), that is, the tendency for new memories to interfere with the retrieval of old memories because they are mixed up with new and somewhat similar memories (retroactive interference goes backwards). For example, if you learn the state capitals this week, new information, such as world capitals, presented to you next week could cause you to become confused about the state capitals (old information). If you start learning French, you may find that you have lost much of your Spanish which you have learnt years before. French has overwritten your Spanish language. A new telephone number may cause you to forget your previous telephone number.

Retroactive interference is generally greatest when the **new learning resembles previous learning (similarities)**, for example, confusing old and new telephone numbers. As for proactive interference, researchers argue that it might occur for two reasons: first, it might be due to **problems in retrieving the correct response** (discriminability); second, it might be due to the great **strength of the incorrect response** learned initially (bias or habit). Thus, we might show proactive interference because the **correct response is very weak** or because the **incorrect response is very strong**.

6.3.4. Repression

Repression is a theory of forgetting in LTM which postulates that **retrieval is impossible due to the threatening nature of material** that cannot, therefore, **access conscious awareness**. Freud (as cited in Brill, 1995) claimed that very **threatening or traumatic memories are often unable to gain access to conscious awareness**. According to him, “The essence of **repression** lies simply in the function of **rejecting and keeping something out of consciousness**”. He sometimes used this concept to refer merely to the inhibition of the capacity for emotional experience.

6.3.5. Cue-Dependent Forgetting

Forgetting often **occurs because we lack the appropriate cues**. Here, information is **available** in LTM, but **cannot be accessed** or rehearsed.

6.4. Conclusion

Retrieval and forgetting are crucial functions that relate to memory. It is of paramount importance to study these two major cognitive processes because they help us gain knowledge of the nature of the human brain and how previously learned information can be restored to deal with new situations and solve problems. It also teaches us to explore the causes of forgetting and how we can reduce its effect on the learning and processing of information.

7. Thinking

7.1. Introduction

Thinking is a major mental process that characterises human beings from other creatures. It is widely studied by a number of disciplines such as psychology, philosophy, biology, and even neurology. In philosophy, thinking is believed as one of the foundations of human existence. This is plainly expressed in the idea of Rene Descartes “I think, therefore, I am”. Thinking allows people to organise their ideas and feelings. It can also be considered one of the basic factors that underlie human behaviour. When we think it helps us make sense of the world around us and interpret it in our own way. Thinking encapsulates a large arena of thought production that can be either conscious or unconscious.

7.2. Definition of Thinking

Scholars gave many definitions to the concept of thinking:

- **Ross:** “Thinking is a mental activity in its cognitive aspect or mental activity with regard to psychological aspects”.
- **Garrett:** “Thinking is a behaviour which is often implicit and hidden and in which symbols are ordinarily employed”.
- **Gilmer:** “Thinking is a problem-solving process in which we use ideas or symbols in place of overt activity”.
- **Mohsin:** “Thinking is an implicit problem-solving behaviour”.

In more comprehensible words, thinking refers to the process of creating a logical series of connections between items of information. Oftentimes, thinking just happens automatically. However, there are times when we consciously think. It may be about how to solve a problem or make a decision. Thinking enables us to connect and integrate new experiences into our existing understanding and perception of how things are.

7.3. Thinking Skills

Thinking skills are cognitive operations or processes that are considered the building blocks of thinking. Our thinking skills, which are developed over a period of time, are used when we try to make sense of experiences, solve problems, make decisions, ask questions, make plans, or organise information. Everybody has thinking skills, but not everyone uses them effectively. Below is a statement of several core thinking skills.

- **Focusing:** attending to selected pieces of information while ignoring other stimuli.
- **Remembering:** storing and then retrieving information from LTM.
- **Gathering:** bringing information needed for cognitive processing to the conscious mind.
- **Organising:** arranging information so it can be used more effectively.
- **Analysing:** breaking down information by examining parts and relationships so that its organisational structure may be understood.
- **Connecting:** making connections between related items or pieces of information.
- **Integrating:** connecting and combining information to better understand the relationship between them.

- **Compiling:** putting parts together to form a whole or building a structure or pattern from diverse elements.
- **Evaluating:** assessing the reasonableness and quality of ideas or materials in order to present and defend opinions.
- **Generating:** producing new information, ideas, products, or ways of viewing things.

7.4. Types of Thinking

As there are many different kinds of thinking, and as the means of categorising these types are also varied, there is no single universally accepted taxonomy. One of the classifications includes the following types:

- **Perceptual (Concrete) thinking:** is the simplest form of thinking; its basis is perception, i.e., interpretation of sensation according to one's experience. It is also called concrete thinking as it is carried out on the perception of actual or concrete objects and events.
- **Conceptual (Abstract) thinking:** is the ability to consider concepts beyond what we observe physically. Here one makes use of concepts, generalised objects and languages. It is regarded as being superior to perceptual thinking as it economises efforts in understanding and problem-solving.
- **Reflective thinking:** is used for solving complex problems, thus it requires reorganisation of all the relevant experiences to a situation or removing obstacles instead of relating with those experiences or ideas. Here mental activity does not involve the mechanical trial and error type of efforts, rather it takes all the relevant facts arranged in a logical order to arrive at a solution to the problem.
- **Creative thinking:** is associated with one's ability to create or construct something new, novel or unusual. It looks for new relationships and associations to describe and interpret the nature of things, events and situations. Here the individual himself usually formulates the evidence and tools for its solution.
- **Non-directed (Associative) thinking:** refers to engagement in a unique type of thinking which is non-directed and without a goal. It is reflected through dreaming and other free-flowing uncontrolled activities. Daydreaming, fantasy and delusions are all kinds of associative thinking which help us escape from the demands of the real world. A person under the influence of such delusions may think or believe that he is a millionaire, the ruler of the universe, a great inventor, or a noted historian.
- **Critical thinking:** involves the use of a set of higher cognitive abilities and skills for the proper conceptualization, interpretation, analysis, synthesis, evaluation and inference, as well as an explanation of the gathered or communicated information. A critical thinker is habitually inquisitive, well-informed, open-minded, flexible, fair-minded in evaluation, and free from personal bias and prejudices. Critical thinking includes two other types of thinking: convergent and divergent thinking.
- **Convergent (Analytical) thinking:** is about bringing facts and data together from various sources and then applying logic and knowledge to solve problems or to make informed decisions.

- **Divergent thinking:** refers to the process of breaking a topic apart to explore its various components and then generating new ideas and solutions.

7.5. Tools of Thinking

There are a few important elements involved in the thinking process:

- **Images:** mental pictures consist of personal experiences of objects, persons or situations, heard and felt. These mental pictures symbolise actual objects, experiences and activities. In thinking, we usually manipulate the images rather than the actual objects, experiences or activities.
- **Concepts:** a concept is a general idea that stands for a general class and represents the common characteristics of all objects or events of this general class. Concepts, as a tool, economise the efforts in thinking, for example, when we hear the word ‘elephant’ we are at once reminded not only about the nature and qualities of elephants as a class but also our own experiences and understanding of them come to the surface in our consciousness to stimulate our thinking at that time.
- **Symbols and signs:** symbols and signs represent and stand for the actual objects, experiences and activities. For example, traffic lights, railway signals, school bells, badges, songs, flags and slogans all are symbolic expressions, they stimulate and motivate resultant thinking because they tell us what to do or how to act.
- **Brain:** whatever may be the role of the muscles, thinking is primarily a function of the brain. Our mind is said to be the chief instrument of the thinking process. The experiences registered by our sense organs have no meaning and thus cannot serve as stimulating agents, or instruments for thinking unless these impressions are received by our brain cells and properly interpreted to derive some meaning. The mental pictures or images can be stored, reconstructed or put to use only on being processed by the brain. What happens in our thought process is simply the function or product of the activities of our brain.
- **Language:** is the most efficient and developed vehicle used for carrying out the process of thinking. When a person reads, writes or hears words or sentences or observes gestures in any language, he is stimulated to think. Thus, reading and writing documents and literature also helps in stimulating and promoting the thinking process.

7.6. Barriers to Effective Thinking

There are many factors which prevent effective thinking. Identifying these factors helps us better understand the process of thinking. Some of the more common barriers are mental set, functional fixedness, stereotypes, and negative transfer.

- **Mental set,** or “entrenchment,” is a frame of mind involving a model that represents a problem, a problem context, or a procedure for problem-solving. When someone has an entrenched mental set, he fixates on a strategy that normally works well with a problem, but not with the problem at hand. A person can become so used to doing things in a certain way that, when the approach stops working, it is difficult for him to switch to a more effective way of doing things.
- **Functional fixedness** is the inability to realise that something known to have a particular use may also be used to perform other functions. That is, the inability to use an object appropriately in a given situation because of prior experience of using the object differently.

When one is faced with a new problem, functional fixedness blocks one's ability to use old tools in novel ways. Functional fixedness is a good example of stereotypical thinking and is a 'block' to problem solutions.

- **Stereotype** is a widely held but fixed and oversimplified image or idea of a particular type of person or thing. The most common kinds of stereotypes are rationally unsupported generalizations about the putative (supposed or assumed) characteristics of all members of a given social group. Many stereotypes, which we learn during childhood, prevent us from seeing individuals or situations differently from what we know about them.
- **Negative transfer** occurs when the process of solving an earlier problem makes later problems harder to solve. It is contrasted with the positive transfer, which occurs when solving an earlier problem makes it easier to solve a later problem. Learning a foreign language, for example, can either hinder or help the subsequent learning of another language.

7.7. Conclusion

This lecture emphasised the importance of thinking in the development of our minds. By understanding the different types of thinking, such as divergent and convergent thinking, and by avoiding its barriers, we can improve our ability to solve problems, make decisions, and communicate effectively. Ultimately, the lecture highlighted the potential of thinking to transform our lives and the world around us and how to cultivate a growth mindset and embrace lifelong learning.

8. Problem Solving

8.1. Introduction

In addition to the types of thinking discussed in the lecture on “Thinking”, there is another common approach to thinking which divides it into the following sub-categories: problem solving, reasoning, and judgment and decision making.

Problem solving is an essential, familiar and pervasive part of everyday life. We engage in problem-solving when we need to overcome obstacles, answer a question, or achieve a goal. If we quickly can retrieve an answer from memory, we do not have a problem. If we cannot retrieve an immediate answer, then we have a problem to be solved.

8.2. Definition of a Problem

According to Dewey (1910), a problem is something that confuses the human mind, challenges it and obscures the belief.

A problem is a case which contains open-ended questions, which attract the attention of an individual and which the individual does not have the necessary algorithm and method knowledge to solve these questions (Bloom & Niss, 1991).

Duncker (1945) offered a concise definition of a problem that captures something of the essence of our everyday experience of problems. He wrote that: “a problem exists when a living organism has a goal but does not know how this goal is to be reached.”

Duncker’s definition determines the notion of a ‘gap’ between a current state and a goal (or desired state). If there are no obstacles preventing the individual from moving from the current state to the desired state, then, there is no problem. Problems, then, consist of **three components**: a *starting state*, a *goal state* and a *set of available actions* to move from the starting state to the goal. If a case is to be a problem, it should be encountered for the first time and it should be new.

8.3. Problem Solving

Problem solving is finding a way and getting rid of the difficulty in addition to reaching the solution (Polya, 1957).

Problem solving is the analysis and solution of tasks or situations that are complex or ambiguous and that pose difficulties or obstacles of some kind (Mayer & Wittrock, 2006).

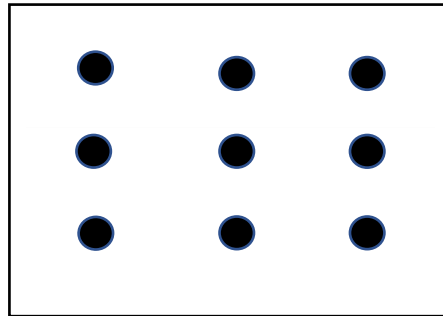
Problem solving is to know what should be done when it is not known what to do. Problem solving process covers wider mental processes and skills than just reaching the correct solution (Sengul & Katranci, 2012).

In sum, problem solving is a systematic search through a range of possible actions to reach a predefined goal. It involves two main types of thinking: **divergent**, in which one tries to generate a diverse set of possible alternative solutions to a problem, and **convergent**, in which one tries to narrow down multiple possibilities to find a single, best answer to a problem. **Multiple-choice**

tests, for example, tend to involve convergent thinking, whereas **essay tests** typically engage divergent thinking.

In **classrooms**, problem solving happens when **teachers** present **tasks** or **challenges** that are deliberately **complex** and for which finding a **solution** is **not straightforward** or obvious. The responses of students to such problems, as well as the strategies for assisting them, show the key features of problem solving. An **example** of a classroom problem solving is given below:

Teacher's instruction: Can you connect all of the dots below using only four straight lines?



8.4. Types of Problems

Psychologists often distinguish between two types of problems: well-structured problems and ill-structured problems.

8.4.1. Well-Structured Problems

Well-structured (well-defined) problems have **clear** solution **paths** and the problem solver is usually able to specify, with relative ease, all the steps that must be taken to reach a solution. The difficulty in such cases, if any, has to do with executing the steps. Most mathematics problems, for example, are well-structured, in the sense that determining what needs to be done is easy, though carrying out the computations needed to reach the solution may be difficult.

8.4.2. Ill-Structured Problems

Ill-structured (ill-defined) problems do **not** have **clear** solution **paths**, and in such cases, the problem solver usually cannot specify the **steps** needed to reach a solution. An example of an ill-structured problem is, “How can a lasting peace be achieved between country A and country B?” It is hard to know precisely what steps one would take to solve this problem. Finding an apartment or conducting a surgical operation on a patient with a tumour in the stomach are two types of ill-structured problems.

The **solution** of ill-structured problems often requires **insight**, which is a distinctive and sudden understanding of a problem or strategy that contributes toward a solution. Insight is the result of much prior thought and hard work and often involves conceptualising a problem or a strategy in a new way. Insight is an **intuitive solution** arrived at when a problem is set aside during **incubation** periods.

Incubation is laying the problem aside for a while and processing it unconsciously (subconsciously). This means that conscious work on the problem is stopped during this period. Psychologists have found that **unconscious incubation** often facilitates solutions. The subconscious mind continues to work towards a solution while the conscious mind focuses on other activities. Incubation is considered an integral part of the **creative** problem solving process.

8.5. Cycle of Problem Solving

Psychologists proposed many approaches to problem solving. One famous strategy was suggested by the American psychologist Robert J. Sternberg. According to him, when we engage in the process of problem solving, we go through the following seven steps: problem identification, problem definition, strategy formulation, organisation of information, resource allocation, monitoring, and evaluation.

- **problem identification:** to recognise the existence of a problem to be solved,
- **problem definition:** to define and represent the problem well enough to determine its nature and understand how to solve it,
- **strategy formulation:** to plan a strategy for solving the problem. The strategy may involve analysis and/or synthesis,
- **organisation of information:** to collect and integrate all the needed information to effectively find a solution to the problem at hand,
- **resource allocation:** to determine the kind and extent of resources needed to solve the problem. These resources include time, effort, money, equipment, space, etc. Some problems are worth a lot of time and other resources. We need to know when to allocate which resources,
- **monitoring:** to check up how the process of solving the problem is going and ensure that the goal is being approached. If necessary, the strategy must be reassessed, and
- **evaluating:** to evaluate the solution at the end of the process. Sometimes the evaluation is immediate, and at other times it can be delayed.

Flexibility is very necessary in following the various steps of this cycle. Successful problem solving may occasionally involve changing the order of the steps, skipping or adding steps when it seems appropriate, and going back and forth through them. We cannot solve all problems following one optimal sequence of steps. How people solve problems depends partly on how they understand them.

8.6. Barriers to Problem Solving

Our ability to solve a problem can be paralysed by a number of obstacles:

- **Mental set:** a mental set is the tendency people have to only use solutions that have worked in the past rather than looking for alternative ideas. A mental set can often work as a heuristic, making it a useful problem-solving tool. However, mental sets can also lead to inflexibility, making it more difficult to find effective solutions.
- **Functional fixedness:** this term refers to the tendency to view problems only in their customary manner. Functional fixedness prevents people from fully seeing all of the different options that might be available to find a solution.

- **Assumptions:** when dealing with a problem, people often make assumptions about the constraints and obstacles that prevent certain solutions.
- **Irrelevant or misleading information:** when you are trying to solve a problem, it is important to distinguish between information that is relevant to the issue and irrelevant data that can lead to faulty solutions. When a problem is very complex, we are easily seduced by focusing on misleading or irrelevant information. Irrelevant information hinders problem solving as it slows the process down, and can cause confusion or misunderstandings.
- **Confirmation bias:** this is about not following the problem solving method, and so introducing bias. This can be the result of missing steps out, or not using them correctly. Confirmation Bias arises when the approach taken is to confirm a preconceived solution. For example, if you feel you already know everything about the problem, you won't perform research or only research things that confirm the appropriateness of the solution you want to use. The tendency to only search for or interpret information that confirms a person's existing ideas. People misinterpret or disregard data that doesn't align with their beliefs.

8.7. Conclusion

Problem solving is a journey, not a destination. There will always be new challenges to confront, but with the tools and frameworks we have discussed in this lecture, you have a strong foundation to approach these challenges with confidence and creativity. Remember that “effective problem solving” is a skill that can be honed through practice.

9. Reasoning

9.1. Introduction

Reasoning is one of the three sub-categories of thinking. It is the central activity in intelligent thinking. We use reasoning in every respect of because it is the process by which we apply knowledge to achieve our goals. Reasoning helps us solve a problem, make a decision, weigh the pros and cons to choose what is best or identify whether an action is positive or negative based on available facts and logic.

Although some problems we encounter can be solved by direct retrieval of solutions from memory, many other problems require the use of reasoning to come to valid solutions and conclusions. Being so, this mental process has received much attention from cognitive psychologists, cognitive scientists, and philosophers.

9.2. Definition of Reasoning

Christopher (1995): “Reasoning is the mental (cognitive) process of looking for reasons for beliefs, conclusions, actions or feelings.” (as cited in Honderich, 1995, p. 748).

Garrett (1968): “Reasoning is a stepwise thinking with a purpose or goal in mind” (as cited in Sarasani, 2007, p. 47).

Gates (1947): “Reasoning is the term applied to highly purposeful, controlled and selective thinking” (as cited in Sarasani, 2007, p. 4).

Skinner (1968): “Reasoning is the word used to describe the mental recognition of cause-and-effect relationships, it may be the prediction of an event from an observed cause or the inference of a cause from an observed event” (as cited in Sarasani, 2007, p. 48).

Psychologists agree that **reasoning** is the **conscious** production of mental thought with the use of **logic**. It involves the **derivation** of inferences by means of the **application** of logical **rules** or laws. An **inference** is a logical **connection** between two **statements**: the first is called the **premise**, while the second is called the **conclusion** and must bear some kind of logical relationship to the premise.

A **premise** is a **proposition** upon which an **argument** is based or from which a conclusion is drawn. That is, a premise includes the **reasons** and **evidence** behind a conclusion. A **conclusion** is a **judgment** or **decision** reached by **reasoning** and after a thorough **analysis** and understanding of the statement.

9.3. Types of Reasoning

Psychologists typically distinguish between two main kinds of reasoning: induction and deduction.

9.3.1. Inductive Reasoning

Inductive reasoning (or **induction**) is one of the two basic types of **inference**. Inductions, specifically, are inferences based on **reasonable probability**. That is, if the premise is **true**, the conclusion is **probably true** as well. Often, Inductive reasoning produces a **general conclusion** from a **specific premise**. Inductions start with particular **observations** of a pattern (premise) and then infer that there is a general **rule** (conclusion). In other words, inductive reasoning starts with the premise and moves to the conclusion. It is reasoning from **parts** to **wholes**, from **particulars** to **generals**, or from the **observed** to the **unobserved**.

Using inductive reasoning generally involves the following questions:

- a. What have you observed? What premise (evidence) is available?
- b. What can you conclude from that premise?
- c. Is that conclusion logical?

Examples:

Premise: Every time I use the can opener, my cat comes running into the kitchen.

Conclusion: The cat probably thinks I am opening a can of tuna or wet food.

Premise: A teacher notices that his students learn better when hands-on activities are incorporated into lessons.

Conclusion: He then decides to regularly include a hands-on component in his future lessons.

9.3.1.1. Types of Inductive Reasoning

There are several major kinds of inductive reasoning, including causal inference, categorical inference, and analogical inference.

9.3.1.1.1. Causal Inference

In **causal** inference, one reasons to the conclusion that something is, or is likely to be, the **cause** of something else. For example, from the fact that one hears the sound of piano music, one may infer that someone is (or was) playing the piano. But although this conclusion may be likely, it is not certain, since the sounds could have been produced by an electronic synthesizer.

9.3.1.1.2. Categorical Inference

In a **categorical** inference, one makes a judgment about whether something is, or is likely to be, a **member** of a certain **category**. For example, upon seeing an animal one has never seen before, a person with limited knowledge of dogs may be confident that what he is seeing is a dog but less certain about the specific species.

9.3.1.1.3. Reasoning by Analogy

In reasoning by **analogy**, one **applies** what one has learned to another **domain**. Aristotle stated the formulae for two possible analogical inferences: “As A is to B, so C is to D”; and “As A is in B, so C is in D.” Analogical inference involves applying the outcomes of a known situation to a new or unknown situation. A risk in this approach, however, can occur if the two situations are too dissimilar to merit the analogous comparison.

9.3.2. Deductive Reasoning

Deductive reasoning is the process of reasoning from one or more general statements regarding what is known to reach a logically certain conclusion (Williams, 2000). It often involves reasoning from one or more general statements regarding what is known to a specific application of the general statement.

Deductive reasoning (or **deduction**) is the second basic type of **inference**. It is based on **absolute logical certainty**. That is, if the **premise** is **true**, the **conclusion** is **certainly true**. Deduction is the basis for mathematics but is also used in formal statements such as definitions or categorisations.

Deductive reasoning begins with the **conclusion** and moves to the **premise** for that conclusion. It involves analysing **valid** forms of **argument** and drawing out the conclusions implicit in their premises. Valid deductive inferences always **guarantee** the truth of their conclusions, in the sense that it is **impossible** for the premises to be true and the conclusion false.

Deductive reasoning generally involves the following questions:

1. What is the conclusion?
2. What premise (evidence) supports it?
3. Is that premise logical?

Examples:

Premise: $2+2 = 4$

Conclusion: $4-2 = 2$

Premise: All gorillas are primates, **and** Koko is a gorilla.

Conclusion: Koko is a primate.

Premise: This dog always barks when someone is at the door, **and** the dog is not barking.

Conclusion: There is no one at the door.

Premise: Sam goes wherever Ben goes, **and** Ben went to the library.

Conclusion: Sam also went to the library.

9.3.2.1. Types of Deductive Reasoning

There are two major types of deductive reasoning, including conditional reasoning and syllogistic reasoning.

9.3.2.1.1. Conditional Reasoning

It is the type of reasoning in which the reasoner must draw a conclusion based on an if-then proposition. The conditional if-then proposition states that if antecedent condition **p** is met, then consequent event **q** follows.

Examples:

If students study hard, **then** they score high on their exams.

Either the current pope is married or he is a divorcé. The current pope is not a divorcé.
Therefore, the current pope is married.

The usual set of conditional propositions from which you can draw a well-reasoned conclusion is, “If p, then q. p. Therefore, q.” This inference illustrates deductive validity. That is, it follows logically from the propositions on which it is based.

9.3.2.1.2. Syllogistic Reasoning

Is the type of reasoning which is based on the use of syllogisms. Syllogisms are deductive arguments that involve drawing conclusions from two premises, each of which shares a term with the conclusion, and shares a common or middle term not present in the conclusion. All syllogisms comprise a major premise, a minor premise, and a conclusion.

Examples:

- All dogs are animals [major premise]; all animals have four legs [minor premise]; therefore, all dogs have four legs [conclusion].
- All mammals are warmblooded [major premise]; whales are mammals [minor premise]; therefore, whales are warmblooded [conclusion].

9.4. Conclusion

Reasoning serves as the cornerstone of critical thinking, guiding us in making informed decisions, solving complex problems, and understanding the world around us. Through the exploration of various types of reasoning, from deductive to inductive, we have uncovered the power and limitations of each approach. Our reasoning skills not only enhance our ability to analyse information but also cultivate a deeper understanding of the interconnectedness of ideas. As we continue to refine our reasoning abilities, let us embrace the intellectual curiosity and open-mindedness necessary to navigate the complexities of the modern world with clarity and purpose.

10. Cognitive Development Theory

Jean Piaget

10.1. Introduction

Jean Piaget (1886–1980) was a famous Swiss biologist and psychologist. He had a big interest in epistemology, the study of knowing, and wanted to know (discover) how we come to know what we know. He disagreed with the idea that intelligence was a fixed **trait**, and regarded cognitive development as a **process** which occurs due to **biological maturation** and **interaction** with the environment (environmental experience). To him, Children **construct** an **understanding** (knowledge) of the world around them, then experience discrepancies between what they already know and what they discover in their environment. He belonged to the **constructivist** school.

His contributions included a **stage** theory of child cognitive development, detailed **observational** studies of **cognition** in children, and a series of simple but ingenious (inventive, creative, original) **tests** to reveal different cognitive abilities.

Piaget's theory of cognitive development, which he formulated in 1936, provided a **systematic study** of **cognitive** development within children and showed that young children **think** in strikingly different ways compared to adults (Wadsworth, 1984). The **goal** of the theory is to **explain** the **mechanisms** and **processes** by which the **infant**, and then the **child**, develops into an individual who can **reason** and **think** using **hypotheses**.

10.2. Characteristics of Cognitive Development Theory

Cognitive development theory differs from other theories in several ways:

- it is concerned with children, rather than all learners,
- it focuses on development, rather than learning per se, so it does not address learning of information or specific behaviours,
- it proposes discrete stages of development, marked by qualitative differences, rather than a gradual increase in the number and complexity of behaviours, concepts, ideas, etc.

10.3. Components of Piaget's Theory

There are three basic components to Piaget's cognitive theory:

- Schema
- Adaptation processes
- Stages of cognitive development

10.3.1. Schema

Piaget believes that children construct knowledge through interaction with the environment. They do this through the use of **schemas**. Piaget (1952) defines a schema as “a cohesive, repeatable action sequence possessing component actions that are tightly interconnected and governed by a core meaning” (p. 7). In other words, schemas are the basic building blocks of intelligent behaviour—a way of organizing knowledge, or, units of knowledge, each relating to one aspect of the world, including objects, actions and abstract (theoretical) concepts.

In more simple terms, a schema can be defined as a **set** of linked **mental representations** of the world (or cognitive structures, a network of concepts, mental maps), which we **use** both to **understand** and **respond** to situations. The assumption is that we **store** these mental representations and **apply** them when **needed**.

Schemas are initially **action-based** (have to do with the child's physical interaction–motor patterns). As children get older, this changes to **mental interaction** with the environment as they are mentally able to represent the world around them. Schemas develop and improve with age from a few **innate reflexes** such as crying or sucking to highly **complex** mental activities.

Piaget believes that new-born babies have a small number of innate schemas—even before they have had many opportunities to experience the world. These neonatal (prenatal) schemas are the cognitive structures underlying **innate reflexes**. These reflexes are genetically **programmed** into us. For example, babies have a **sucking** reflex, which is triggered by something touching the baby's lips. A baby will suck a comforter (dummy) or a person's finger. Piaget, therefore, assumed that the baby has a 'sucking schema'. Similarly, the **grasping** reflex which is elicited when something touches the palm of a baby's hand, or the **rooting** reflex, in which a baby will turn its head towards something which touches its cheek, are all innate schemas. Shaking a rattle would be the combination of two schemas, grasping and shaking.

When Piaget talked about the **development** of a person's mental processes, he was referring to increases in the **number** and **complexity** of the **schemas** that a person had learned. Schemas keep developing by means of adaptation processes.

10.3.2. Adaptation Processes

Piaget viewed intellectual growth as a process of **adaptation** (adjustment) to the world. This happens through two major processes: assimilation and accommodation (Wadsworth, 2004).

10.3.2.1. Assimilation

This process refers to the child's **use** of an **existing** schema to deal with a **new** object or situation (to interpret the external world). This happens when the child **incorporates** new information that is similar to the information in his current schemas (assimilate). Here, the schemas are in a state of **equilibrium** (no change to the schemas)

Example of assimilation:

A 2-year-old child sees a man who is bald on top of his head and has long frizzy hair on the sides. To his father's horror, the toddler shouts "Clown, clown."

10.3.2.2. Accommodation

It is the process by which the child **adjusts** the existing schemas (knowledge) to better fit the environment. This happens when the existing schema does not work and needs to be changed to deal with a new object or situation (accommodate). This creates **disequilibrium** in the schemas because the new information does not fit into the existing schemas.

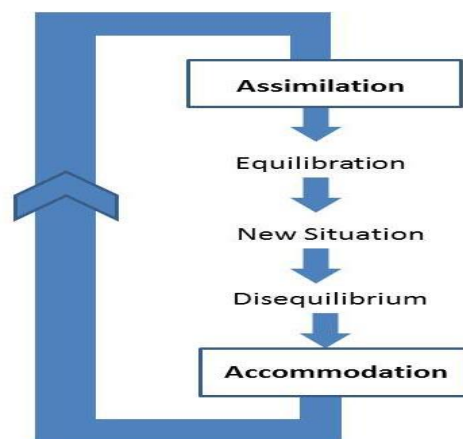
Example of accommodation:

In the "clown" incident, the boy's father explained to his son that the man was not a clown and that even though his hair was like a clown's, he wasn't wearing a funny costume and wasn't doing silly things to make people laugh. With this new knowledge, the boy was able to change his schema of "clown" and make this idea fit better to a standard concept of "clown".

The processes of assimilation and accommodation keep going on until the child's schemes become more and more **complex**. **Equilibrium** occurs when a child's schemas can deal with most new information through assimilation. However, an unpleasant state of **disequilibrium** occurs when new information cannot be fitted into existing schemas (through assimilation).

10.3.2.3. Equilibration

Equilibration is the **force** which moves **development** along and drives the **learning** process as we do not like to be frustrated and will seek to restore **balance** by mastering the new challenge (accommodation). Once the new information is acquired the process of assimilation with the new schema will continue until the next time we need to make an adjustment to it. Piaget believed that cognitive development did not progress at a steady rate, but rather in leaps and bounds.



10.3.3. Stages of Cognitive Development

Piaget proposed **four** stages of cognitive development which reflect the increasing sophistication of children's thought. These stages have the following characteristics:

- *universal* (characterize children everywhere and apply to all cultures around the world),
- *invariant* (children go through these stages in the same order),
- *discontinuous* (development is a progression of discontinuous stages—e.g., ladybug)

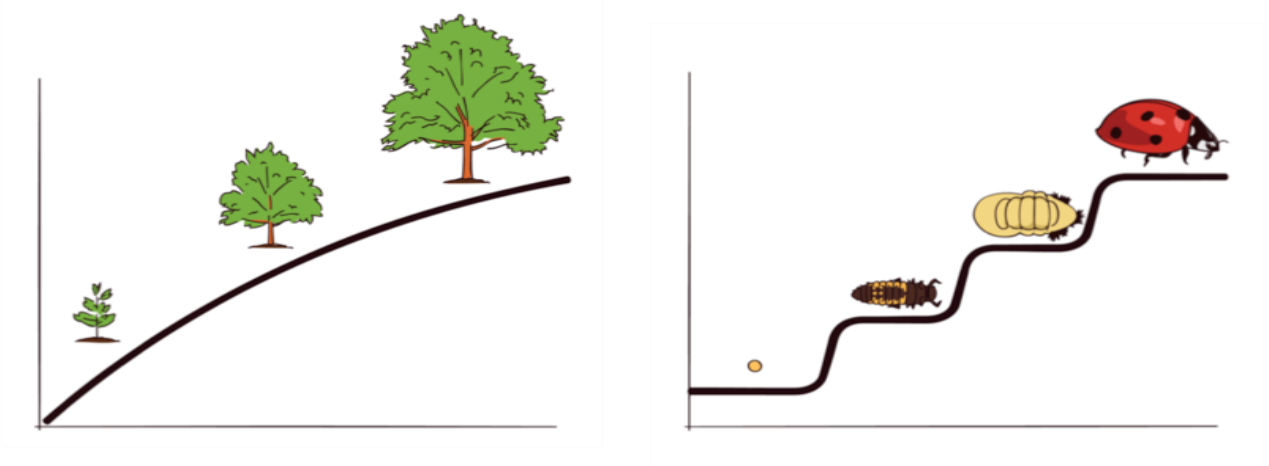


Figure 1. Continuous development (gradual, quantitative changes) and discontinuous development (sudden, qualitative changes) of a pine tree and a ladybug (egg, larva, pupa, adult ladybug).

10.3.3.1. Sensory-Motor Stage (birth–2 years)

This stage is all about building schemas through sensory and motor (physical) exploration of the environment (interaction). The child (infant) is conscious (aware) of the environment, but has no self-consciousness (e.g., the experience of the one-year-old James and the mirror, which showed that James did not know that he was seeing himself—no sense of recognition). The infant’s thinking is restricted to what comes within his sensation: what we sense is what we get (direct sensation).

At this stage, there is no intentional behaviour. A stimulus induces a predictable motor response. That is, the child senses the world, and acts in response to his/her impressions without reflection or analysis.

This stage is characterized by two main achievements:

- Object permanence (8 or 9 months–up): children begin to understand that an **object** continues to **exist** even when they can’t see it (experience of the baby and the toy). Piaget says that children at this age realize that objects are **permanent entities** (even when they don’t see them)
- Mental representation (18–24 months): the ability to internalize **mental** representation of the world. It is the basis for things like role-play, pretend-play. This is one of the building blocks for memory (i.e., you have to put something in your mind so that you can remember it).

10.3.3.2. Preoperational Stage (2–7 years)

This stage is associated with toddlerhood and preschool age and is mainly characterized by symbolic thinking, egocentrism and anthropomorphism.

- Symbolic thinking: the ability to make mental representations (images) of things which are not around us. Children become increasingly adept at using symbols as evidenced by pretend play (e.g., pretending a broom is a horse) and symbolic play (e.g., playing the roles of a mother, a doctor, etc.). By this stage, the child’s vocabulary skyrockets to reach 10,000 words. We gain vocabulary skills early in life because of our fundability to use symbolic thinking. This means that every word we know is a symbol of an idea. Children are **unable to decentre their thinking** (think about more than one aspect of a problem at a time).
- Egocentrism: is the tendency to see the world from one’s own perspective, or a tendency to perceive oneself as the centre of the universe. Egocentric children think that all people see things in the world as they themselves do, that is; they are unable to understand that different people see the world in a way that is different from theirs (experiment of the three mountains, the girl and the doll). For instance, because of egocentric thinking, preoperational children hide by only covering their eyes or parts of their bodies believing that if they can’t see the seeker, they themselves can’t be seen.
- Anthropomorphism: comes from two Greek words, *anthropo*, meaning “man or human being”, and *morphe*, meaning “form or shape”. It is the process of assigning human characteristics and behaviours to non-human entities (like animals or objects). For example, making an animal speak and feel like a human in a cartoon or movie. In other words, a tendency to explain natural events in terms of human behaviour.

10.3.3.3. Concrete Operational (7-11 years)

Piaget considered the concrete stage a major turning point in the child's cognitive development because it marks the beginning of **logical or operational thought**. Children start thinking in terms of cause and effect and are able to solve problems in a logical manner. However, most of the thinking is concrete: cognitive processes deal with what can be seen or experienced, not with abstractions. For example, $3 + 7 = 10$, this is ok, but $x + 8 = 10$ is difficult as the child finds it difficult to grasp that “x” is a variable which can have various numerical values in different problems.

Children start using inductive logic (inductive reasoning), which involves going from a specific experience to a general principle. For example, every time you are around a cat, you have itchy eyes, a runny nose, and a swollen throat, you might then reason that you are allergic to cats. On the other hand, children at this age have difficulty using deductive logic, which involves using a general principle to determine the outcome of a specific event. For example, a child might learn that $A=B$, and $B=C$, but might still struggle to understand that $A=C$.

Conservation ability is another characteristic of this stage. It is the understanding that something stays the same in quantity even though its appearance changes. Children can conserve, classify and categorize, and engage in spatial reasoning (using maps, giving directions). They can conserve number at 6, mass at 7, and weight at 9. At this stage, children can also **decentre their thinking**, which means thinking about multiple things at one time.

10.3.3.4. Formal Operational Stage (11 years-up)

It is associated with adolescence and is characterized by abstract thinking which we continue to work on for the rest of our life. This stage gets more and more advanced with age and experience. Children can engage in hypothetical scientific reasoning (abstract thought). Children are able to think about abstract concepts and test hypotheses logically, understand algebra and think about thinking (meta-thought/meta-cognition). They can reflect, analyse, and rethink ideas and viewpoints. They can also solve problems they have little experience with by developing hypotheses (theories) and evaluating them in a systematic manner to gather the most reliable and valid evidence—hypothetico-deductive reasoning.

Operating abstractly means that we no longer need to touch, feel or experience in order to understand things because we can just figure things out in our heads. At this stage, we can figure out how we deal with a new situation or solve a new problem based on the experiment we can carry out in our heads.

10.4. Educational Implications

Piaget did not explicitly relate his theory to education, although later researchers have explained how features of Piaget's theory can be applied to teaching and learning. Piaget has been extremely influential in developing educational policy and teaching practices in many countries of the world. Below is a statement of some representations of Piaget's theory in the field of education.

- Discovery learning: the idea that children learn best through doing and actively exploring,
- Notion of readiness: concepts taught according to the appropriate stage of cognitive development,
- Assimilation and accommodation: require an active learner, not a passive one, because problem-solving skills cannot be taught, they must be discovered.
- Teaching: should be student-centred and accomplished through active discovery learning,

- Teacher: acts as a facilitator and should:
 - ✓ focus on the process of learning, rather than the end product of it,
 - ✓ use active methods that require rediscovering or reconstructing "truths",
 - ✓ encourage collaborative activities so that children can learn from each other,
 - ✓ devise situations that present useful problems, and create disequilibrium in the child.
 - ✓ evaluate the level of the child's development, so suitable tasks can be set.

10.5. Conclusion

This theory is a blueprint (plan, design, sketch ...) for cognitive development as it captures the spectrum (position on a scale) of thinking from its primitive beginning to its most sophisticated level. It has ever been the driving force for many pieces of research and debates among researchers and practitioners. It has also contributed a lot to the improvement of the field of teaching with regard to syllabus design, teaching methods and textbook conceptualisation.

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