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Dr. Assia BAGHDADI

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Dr.Assia BAGHDADI

Third-year LMD

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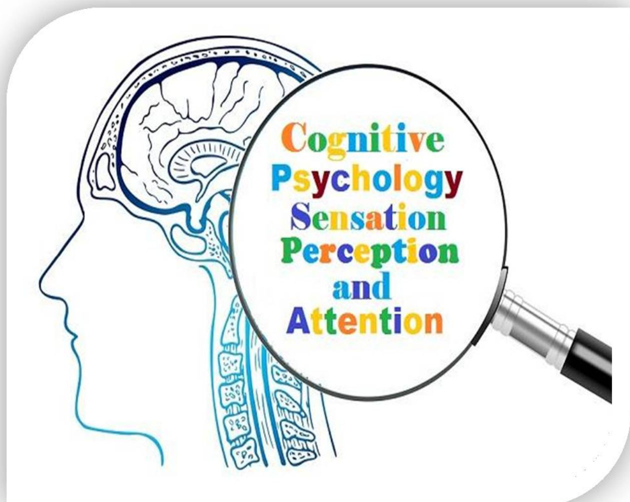

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Course Book

- Cognitive Psychology -

Prepared by

Dr. Assia BAGHDADI

Preface

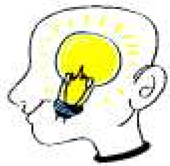
Cognitive psychology is the field of psychology dealing with cognitive mental processes. It is the study of how we perceive and understand information from the world around us, how we integrate this new knowledge with our previous experiences, and how we adapt to a constantly changing environment.

This course book of cognitive psychology is designed for EFL third-year students (Licence) to provide them with a comprehensive overview of topics related to the information-processing mechanisms of the mind, including consciousness, perception, attention, memory, conceptual knowledge, intelligence, creativity ….etc. The course is structured to achieve the following goals:

- Demonstrating knowledge and understanding of well established theories in cognitive psychology.
- Comprehending and appreciating the complexity of cognitive processes.
- Appreciating research and theories of cognition from diverse fields of study.
- Acquiring an understanding of research methods in cognitive psychology

At the end of each chapter, the student finds questions to assist him ensure that he has understood the fundamentals and that he can think about the content in a variety of ways (factual, analytical, creative, and practical).

Dr. Assia Baghdadi



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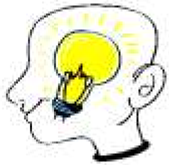
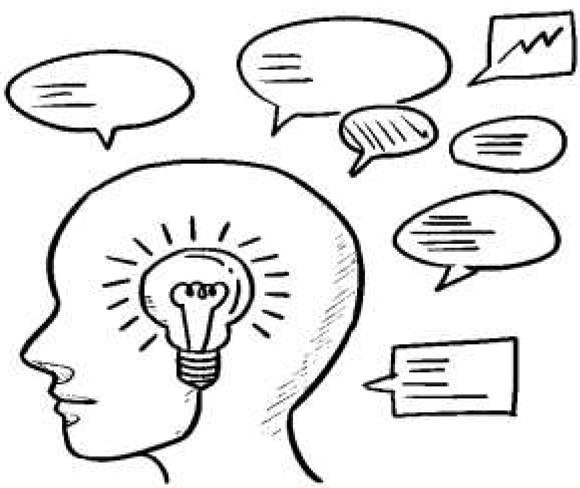


Chapter I: Introduction to Cognitive Psychology



1. Cognitive psychology definition

The word "cognition" comes from the Latin word “cognoscere”, which means "to know" or "to come to know." As a result, cognition encompasses the activities and processes involved in the acqusition, storage, retrieval, and processing of information. In other words, it could involve the mechanisms that assist us in perceiving, attending, remembering, thinking, categorizing, reasoning, and making decisions.

As the name indicates, cognitive psychology is the field of psychology dealing with cognitive mental processes. Cognitive psychology, according to Sternberg (1999), is “the study of how people interpret, understand, remember, and think about information.” In 2005, Solso provided a new concept of cognitive psychology, stating that it is the study of the mechanisms that underpin mental events. In general, cognitive psychology is the field of psychology dealing with how people learn, store, turn, use, and communicate language.

Cognitive psychologists study the different cognitive mechanisms that make up this branch of science. These processes include attention, which is the process by which we concentrate on a stimulus; perception, which is the process by which we perceive sensory input; pattern recognition, which is the process by which we classify stimuli into known categories; and memory, which is the process by which we recall information. As a result, cognitive psychologists' research extended to a variety of fields, as seen below:

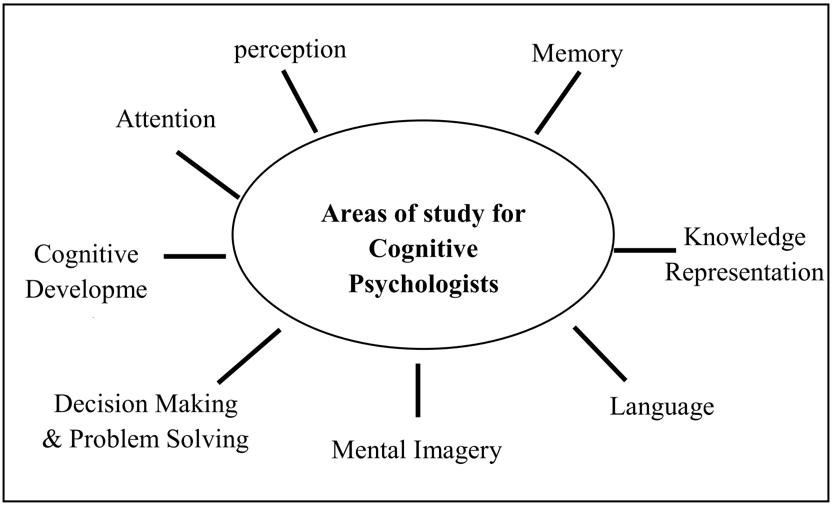


Figure (01): Research fields related to Cognitive Psychology (Sternberg, 1999)

2. Roots of Psychology

- **Rationalism versus Empiricism**

Where and when did the study of cognitive psychology begin? Historians of psychology usually trace the earliest roots of psychology to two approaches to understanding the human mind:

- **Philosophy** seeks to understand the general nature of many aspects of the world, in part through introspection, the examination of inner ideas and experiences (from intro-,“ inward, within,” and -spect,“look”);
- **Physiology** seeks a scientific study of life-sustaining functions in living matter, primarily through empirical (observation-based) methods.

Two Greek philosophers, Plato (ca. 428–348 B.C.) and his student Aristotle (384–322 B.C.), have profoundly affected modern thinking in psychology and many other fields. Plato and Aristotle disagreed regarding how to investigate ideas.

Plato was a rationalist. A rationalist believes that the route to knowledge is through thinking and logical analysis. That is, a rationalist does not need any experi-ments to develop new knowledge. A rationalist who is interested in cognitive pro-cesses would appeal to reason as a source of knowledge or justification.

In contrast, Aristotle (a naturalist and biologist as well as a philosopher) was an empiricist. An empiricist believes that we acquire knowledge via empirical evidence that is, we obtain evidence through experience and observation. In order to explore how the human mind works, empiricists would design experiments and conduct studies in which they could observe the behavior and processes of interest to them. Empiricism therefore leads directly to empirical investigations of psychology.

In contrast, rationalism is important in theory development. Rationalist theories without any connection to observations gained through empiricist methods may not be valid; but mountains of observational data without an organizing theoretical framework may not be meaningful.

We might see the rationalist view of the world as a thesis and the empirical view as an antithesis. Most psychologists today seek a synthesis of the two. They base empirical observations on theory in order to explain what they have observed in their experiments. In turn, they use these observations to revise their theories when they find that the theories cannot account for their real-world observations.

The contrasting ideas of rationalism and empiricism became prominent with the French rationalist **René Descartes** (1596–1650) and the British empiricist John Locke (1632–1704).

Descartes viewed the introspective, reflective method as being superior to empirical methods for finding truth. The famous expression “cogito, ergo sum” (I think, therefore I am) stems from Descartes. He maintained that the only proof of his existence is that he was thinking and doubting. Descartes felt that one could not rely on one’ s senses because those very senses have often proven to be deceptive (think of optical illusions, for example).

Locke, in contrast, had more enthusiasm for empirical observation (Leahey, 2003). Locke believed that humans are born without knowledge and therefore must seek knowledge through empirical ob-servation. Locke’s term for this view was tabula rasa (meaning “ blank slate” in Latin). The idea is that life and experience “ write” knowledge on us. For Locke, then, the study of learning was the key to understanding the human mind. He believed that there are no innate ideas.

In the eighteenth century, German philosopher **Immanuel Kant** (1724-1804) dialectically synthesized the views of Descartes and Locke, arguing that both ratio-nalism and empiricism have their place. Both must work together in the quest for truth. Most psychologists today accept Kant ’s synthesis.

3. Psychological Antecedents of Cognitive Psychology

Cognitive psychology has roots in many different ideas and approaches. The approaches that will be examined include early approaches such as structuralism and functionalism, followed by a discussion of associationism, behaviorism, and Gestalt psychology.

3.1.Understanding the Structure of the Mind: Structuralism

Structuralism seeks to understand the structure (configuration of elements) of the mind and its perceptions by analyzing those perceptions into their constituent components (affection, attention, memory, sensation, etc.).

Wilhelm Wundt (1832–1920) was a German psychologist whose ideas contributed to the development of structuralism. Wundt is often viewed as the founder of structuralism in psychology. Wundt used a variety of methods in his research. One of these methods was **introspection.** Introspection is a deliberate looking inward at pieces of information passing through consciousness. The aim of introspection is to look at the elementary components of an object or process.

The introduction of introspection as an experimental method was an important change in the field because the main emphasis in the study of the mind shifted from a rationalist approach to the empiricist approach of trying to observe behavior in order to draw conclusions about the subject of study. The method of introspection has some challenges associated with it.

- First, people may not always be able to say exactly what goes through their mind or may not be able to put it into adequate words.
- Second, what they say may not be accurate.
- Third, the fact that people are asked to pay attention to their thoughts or to speak out loud while they are working on a task may itself alter the processes that are going on.

Wundt had many followers. One was an American student, Edward Titchener (1867–1927). Titchener (1910) is sometimes viewed as the first full-fledged structuralist. In any case, he certainly helped bring structuralism to the United States. His experiments relied solely on the use of introspection, exploring psychology from the vantage point of the experiencing individual. Other early psychologists criticized both the method (introspection) and the focus (elementary structures of sensation) of structuralism. These critiques gave rise to a new movement—functionalism.

3.2.Understanding the Processes of the Mind: Functionalism

Functionalism, a counter-argument to structuralism, proposed that psychologists should concentrate on the mechanisms of thought rather than the contents of thought. Functionalism tries to figure out why people do what they do.

In comparison to the structuralists, who wanted to know what the basic contents (structures) of the human mind are, this central question about processes was raised. The study of the mechanisms of how and why the mind functions as it does, according to functionalists, is the key to understanding the human mind and actions.

Functionalists were unified by the kinds of questions they asked but not necessarily by the answers they found or by the methods they used for finding those answers. Because functionalists believed in using whichever methods best answered a given researcher's questions, it seems natural for functionalism to have led to pragmatism. Pragmatists believe that knowledge is validated by its usefulness: What can you do with it? Pragmatists are concerned not only with knowing what people do; they also want to know what we can do with our knowledge of what people do. For example, pragmatists believe in the importance of the psychology of learning and memory. Why? Because it can help us improve the performance of children in school. It can also help us learn to remember the names of people we meet.

A leader in guiding functionalism toward pragmatism was William James (1842–1910). His chief functional contribution to the field of psychology was a single book: his landmark Principles of Psychology (1890/1970). Even today, cognitive psychologists frequently point to the writings of James in discussions of core topics in the field, such as attention, consciousness, and perception.

John Dewey (1859–1952) was another early pragmatist who profoundly influenced contemporary thinking in cognitive psychology. Dewey is remembered primarily for his pragmatic approach to thinking and schooling. Although functionalists were interested in how people learn, they did not really specify a mechanism by which learning takes place. This task was taken up by another group, Associationists. An Integrative Synthesis: As

3.3.An Integrative Synthesis: Associationism

Associationism, like functionalism, was more of an influential way of thinking than a rigid school of psychology. Associationism examines how elements of the mind, like events or ideas, can become associated with one another in the mind to result in a form of learning. For example, associations may result from:

• contiguity (associating things that tend to occur together at about the same time);

• similarity (associating things with similar features or properties); or

• contrast (associating things that show polarities, such as hot/cold, light/dark, day/ night).

Hermann Ebbinghaus (1850–1909) was the first experimenter to apply associationist principles systematically. Another influential associationist, Edward Lee Thorndike (1874–1949), held that the role of "satisfaction" is the key to forming associations. Thorndike termed this principle the law of effect (1905). A stimulus will tend to produce a certain response over time if an organism is rewarded for that response.

3.4.Behaviorism

Behaviorism focuses only on the relation between observable behavior and environmental events or stimuli. The idea was to make physical whatever others might have called "mental" (Lycan, 2003).

The "father" of radical behaviorism is John Watson (1878–1958). Watson had no use for internal mental contents or mechanisms. He believed that psychologists should concentrate only on the study of observable behavior (Doyle, 2000). He dismissed thinking as nothing more than subvocalized speech. Behaviorism also differed from previous movements in psychology by shifting the emphasis of experimental research from human to animal participants. One problem with using nonhuman animals, however, is determining whether the research can be generalized to humans (i.e., applied more generally to humans instead of just to the kinds of nonhuman animals that were studied).

B. F. Skinner (1904–1990), an other prominent radical behaviorist, believed that virtually all forms of human behavior, not just learning, could be explained by behavior emitted in reaction to the environment and he rejected mental mechanisms. He believed instead that operant conditioning—involving the strengthening or weakening of behavior, contingent on the presence or absence of reinforcement (rewards) or punishments—could explain all forms of human behavior. Skinner applied his experimental analysis of behavior to many psychological phenomena, such as learning, language acquisition, and problem solving. Largely because of Skinner's towering presence, behaviorism dominated the discipline of psychology for several decades.

Behaviorism was challenged on many fronts like language acquisition, production, and comprehension. **First,** although it seemed to work well to account for certain kinds of learning, behaviorism did not account as well for complex mental activities such as language learning and problem solving. **Second,** more than understanding people's behavior, some psychologists wanted to know what went on inside the head. **Third,** it often proved easier to use the techniques of behaviorism in studying nonhuman animals than in studying human ones.

3.5.The Whole Is More than the Sum of its Parts: Gestalt Psychology

Gestalt psychology states that we best understand psychological phenomena when we view them as organized, structured wholes. According to this view, we cannot fully understand behavior when we only break phenomena down into smaller parts. For example, behaviorists tended to study problem solving by looking for sub-vocal processing—they were looking for the observable behavior through which problem solving can be understood. Gestaltists, in contrast, studied insight, seeking to understand the unobservable mental event by which someone goes from having no idea about how to solve a problem to understanding it fully in what seems a mere moment of time.

The maxim “the whole is more than the sum of its parts” aptly sums up the Gestalt perspective. To understand the perception of a flower, for example, we would have to take into account the whole of the experience. We could not understand such a perception merely in terms of a description of forms, colors, sizes, and so on. Similarly, as noted in the previous paragraph, we could not understand problem solving merely by looking at minute elements of observable behavior (Köhler, 1940; Wertheimer, 1959).

4. Emergence of Cognitive Psychology

In the early 1950s, a movement called the “cognitive revolution” took place in response to behaviorism. Cognitivism is the belief that much of human behavior can be understood in terms of how people think. It rejects the notion that psychologists should avoid studying mental processes because they are unobservable. Cognitivism is, in part, a synthesis of earlier forms of analysis, such as behaviorism and Gestaltism. Like behaviorism, it adopts precise quantitative analysis to study how people learn and think; like Gestaltism, it emphasizes internal mental processes.

4.1.Early Role of Psychobiology

Ironically, one of Watson’s former students, Karl Spencer Lashley (1890–1958), brashly challenged the behaviorist view that the human brain is a passive organ merely responding to environmental contingencies outside the individual (Gardner, 1985). Instead, Lashley considered the brain to be an active, dynamic organizer of behavior. Lashley sought to understand how the macro-organization of the human brain made possible such complex, planned activities as musical performance, game playing, and using language. None of these activities were, in his view, readily explicable in terms of simple conditioning.

In the same vein, but at a different level of analysis, Donald Hebb (1949) proposed the concept of cell assemblies as the basis for learning in the brain. Cell assemblies are coordinated neural structures that develop through frequent stimulation.

They develop over time as the ability of one neuron (nerve cell) to stimulate firing in a connected neuron increases. Behaviorists did not jump at the opportunity to agree with theorists like Lashley and Hebb. In fact, behaviorist B. F. Skinner (1957) wrote an entire book describing how language acquisition and usage could be explained purely in terms of environmental contingencies. This work stretched Skinner's framework too far, leaving Skinner open to attack.

An attack was indeed forthcoming. Linguist Noam Chomsky (1959) wrote a scathing review of Skinner's ideas. In his article, Chomsky stressed both the biological basis and the creative potential of language. He pointed out the infinite numbers of sentences we can produce with ease. He thereby defied behaviorist notions that we learn language by reinforcement.

Even young children continually are producing novel sentences for which they could not have been reinforced in the past.

4.2.Engineering, Computation, and Applied Cognitive Psychology

By the end of the 1950s, some psychologists were intrigued by the tantalizing notion that machines could be programmed to demonstrate the intelligent processing of information (Rychlak & Struckman, 2000). Turing (1950) suggested that soon it would be hard to distinguish the communication of machines from that of humans.

He suggested a test, now called the “Turing test,” by which a computer program would be judged as successful to the extent that its output was indistinguishable, by humans, from the output of humans (Cummins & Cummins, 2000). In other words, suppose you communicated with a computer and you could not tell that it was a computer. The computer then passed the Turing test (Schonbein & Bechtel, 2003).

By 1956 a new phrase had entered our vocabulary: **Artificial intelligence (AI)** which is the attempt by humans to construct systems that show intelligence and, particularly, the intelligent processing of information (Merriam-Webster’s Collegiate Dictionary, 2003). Chess-playing programs, which now can beat most humans, are examples of artificial intelligence. However, experts greatly underestimated how difficult it would be to develop a computer that can think like a human being. Even today, computers have trouble reading handwriting and understanding and responding to spoken language with the ease that humans do.

Many of the early cognitive psychologists became interested in cognitive psychology through applied problems. For example, during World War II, many cognitive psychologists, including one of the senior author’s advisors, Wendell Garner, consulted with the military in solving practical problems of aviation and other fields that arose out of warfare against enemy forces. Information theory, which sought to understand people’s behavior in terms of how they process the kinds of bits of information processed by computers (Shannon & Weaver, 1963), also grew out of problems in engineering and informatics.

Applied cognitive psychology also has had great use in advertising. John Watson, after he left Johns Hopkins University as a professor, became an extremely successful executive in an advertising firm and applied his knowledge of psychology to reach his success. Indeed, much of advertising has directly used principles from cognitive psychology to attract customers to products (Benjamin & Baker, 2004).

By the early 1960s, developments in psychobiology, linguistics, anthropology, and artificial intelligence, as well as the reactions against behaviorism by many mainstream psychologists, converged to create an atmosphere ripe for revolution.

Early cognitivists (e.g. , Galanter, & Pribram, 1960; Newell, Shaw, & Simon,1957b) argued that traditional behaviorist accounts of behavior were inadequate precisely because they said nothing about how people think.

Ulric Neisser's book Cognitive Psychology (Neisser, 1967) was especially critical in bringing cognitivism to prominence by informing undergraduates, graduate students, and academics about the newly developing field.

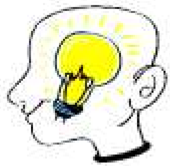
Neisser defined cognitive psychology as the study of how people learn, structure, store, and use knowledge. Subsequently, Allen Newell and Herbert Simon (1972) proposed detailed models of human thinking and problem solving from the most basic levels to the most complex. By the 1970s cognitive psychology was recognized widely as a major field of psychological study with a distinctive set of research methods.

In the 1970s, Jerry Fodor (1973) popularized the concept of the modularity of mind. He argued that the mind has distinct modules, or special-purpose systems, to deal with linguistic and, possibly, other kinds of information. Modularity implies that the processes that are used in one domain of processing, such as the linguistic (Fodor, 1973) or the perceptual domain (Marr, 1982), operate independently of processes in other domains.

An opposing view would be one of domain-general processing, according to which the processes that apply in one domain, such as perception or language, apply in many other domains as well. Modular approaches are useful in studying some cognitive phenomena, such as language, but have proven less useful in studying other phenomena, such as intelligence, which seems to draw upon many different areas of the brain in complex interrelationships.

Comprehension Check

- ♣ How does cognitivism incorporate elements of the schools that preceded it?
- ♣ What is pragmatism, and how is it related to functionalism?
- ♣ How are associationism and behaviorism both similar and different?
- ♣ What is the fundamental idea behind Gestalt psychology?



Chapter II: Anatomy and Mechanisms of Human Brain

1. Definition

The brain is the organ in our bodies that most directly controls our thoughts, emotions, and motivations (Rockland, 2000). Cognitive neuroscience is the field of study linking the brain and other aspects of the nervous system to cognitive processing and, ultimately, to behavior.

2. Cognition in the Brain: The Anatomy and Mechanisms of the Brain

The brain has three major regions: forebrain, midbrain, and hindbrain. These labels do not correspond exactly to locations of regions in an adult or even a child's head. Rather, the terms come from the front-to-back physical arrangement of these parts in the nervous system of a developing embryo.

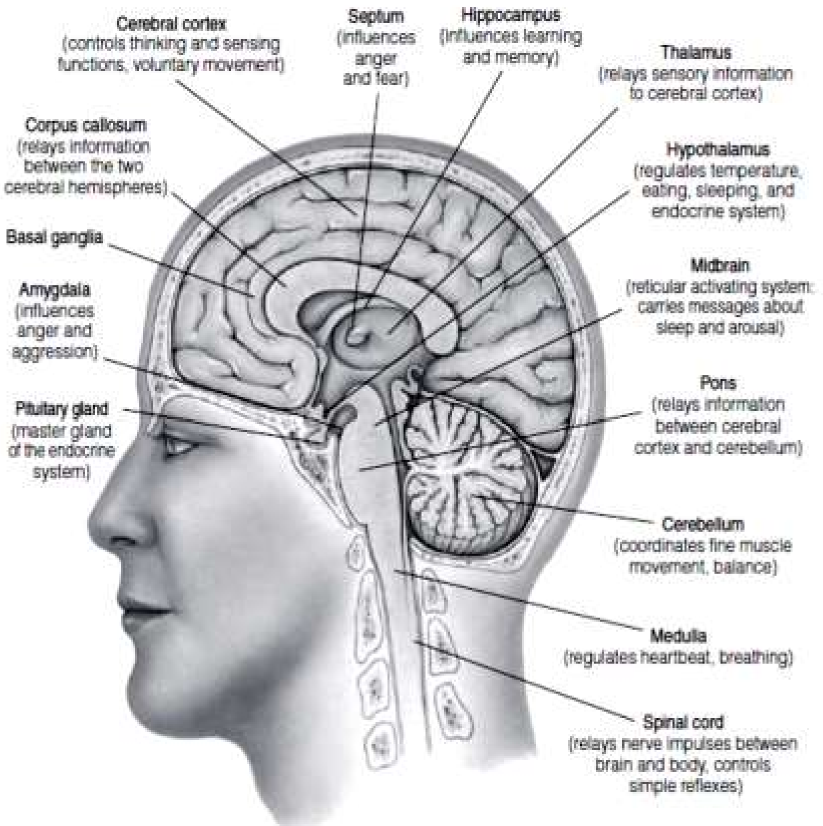


Figure (02): Structures of the Brain (Sternberg, 2000)

The following table sums up the major structures of the Brain and their functions

Region of the Brain	Major Structures within the Regions	Function of the Structures
Forebrain	Cerebral cortex (outer layer of the cerebral hemispheres)	Involved in receiving and processing sensory information, thinking other cognitive processing, and planning and sending motor information.
	Basal ganglia (collections of nuclei and neural fibers)	Crucial to the function of the motor system
	Limbic systems (hippo campus, amygdale, and septum)	Involved in leaming, emotions, and motivation (in particular, the hippocampus in flounces learning and memory, the amygdale influences anger and aggression, and the septum influence anger and fear)
	Thalamus	Primary relay station for sensory information coming into the brain, transmits information to the correct regions of the cerebral cortex through projection fibers that extend from the thalamus to specific regions of the cortex, comprises several nudel (groups of neurons) that receive specific kinds of sensory information and project that information to specific regions of the cerebral cortex, in duding four key nudel for sensory information. (1) from the visual receptors, via optic nerves, to the visual cortex, permitting us to see, (2) from the auditory receptors, via auditory nerves, to the auditory cortex, permitting us to hear, (3) fro; sensory receptors in the somatic nervous system, to the primary so-mat sensory cortex permitting us to sense pressure and pain, and (4) from the cerebellum (in the hindbrain) to the primary motor cortex, permitting us to sense physical balance and equilibrium.
	Hypothalamus	Controls the endocrine system, controls the autonomic nervous system, such as internal temperature regulation, appetite and thirst regulation, and other key functions, in evolved in regulation of behavior related to species survival (in particular fighting feeding fleeing, and mating), plays a role in controlling consciousness. (see reticular activating system)m involved in emotions pleasure, pain, and stress tractions.
Midbrain	Superior colliculi (an top)	involved in vision (especially visual reflexes)
	Inferior colliculi (below)	Involved in hearing.

Region of the Brain	Major Structures within the Regions	Function of the Structures
Forebrain	Reticular activating system (also extends info the hindbrain).	Important in controlling consciousness (sleep arousal), attention, cardio respiratory function, and movement.
	Gray matter, red nucleus, substantia nigra, ventral region.	Important in controlling movement.
Hindbrain	Cerebellum	Essential to balance, coordination, and mused tone
	Pons (also contains part of the RAS).	Involved in consciousness (sleep and arousal), bridges neural transmissions from one part of the brain to another, involved with facial nerves.
	Medulla oblongata	Serves as juncture at which nerves cross from one side of the body to opposite side of the brain, involved in cardio respiratory function, digestion, and swallowing.

Table (01): Major structures and Functions of the Brain (Sternberg, 2000)

3. Cerebral Cortex and Localization of Function

The cerebral cortex forms the outer layer of the two halves of the brain—**the left** and **right cerebral hemispheres** (Galaburda & Rosen, 2003). Although the two hemispheres appear to be quite similar, they function differently. **The left cerebral hemisphere** is specialized for some kinds of activity whereas **the right cerebral hemisphere** is specialized for other kinds. For example, receptors in the skin on the right side of the body generally send information through the medulla to areas in the left hemisphere in the brain. The receptors on the left side generally transmit information to the right hemisphere.

Similarly, the left hemisphere of the brain directs the motor responses on the right side of the body. The right hemisphere directs responses on the left side of the body. Figure **(03)** shows clearly the functional areas of the cortex**.**

However, not all information transmission is contralateral—from one side to another (contra-, "opposite"; lateral, "side"). Some ipsilateral transmission—on the same side—occurs as well. For example, odor information from the right nostril goes primarily to the right side of the brain. About half the information from the right eye goes to the right side of the brain, the other half goes to the left side of the brain.

In addition to this general tendency for contralateral specialization, the hemispheres also communicate directly with one another. The corpus callosum is a dense aggregate of neural fibers connecting the two cerebral hemispheres (Witelson, Kigar, & Walter, 2003). It allows transmission of information back and forth. Once information has reached one hemisphere, the corpus callosum transfers it to the other hemisphere.

If the corpus callosum is cut, the two cerebral hemispheres—the two halves of the brain—cannot communicate with each other (Glickstein & Berlucchi, 2008). Although some functioning, like language, is highly lateralized, most functioning—even language—depends in large part on integration of the two hemispheres of the brain. The following figure shows clearly the functional areas of the cortex.

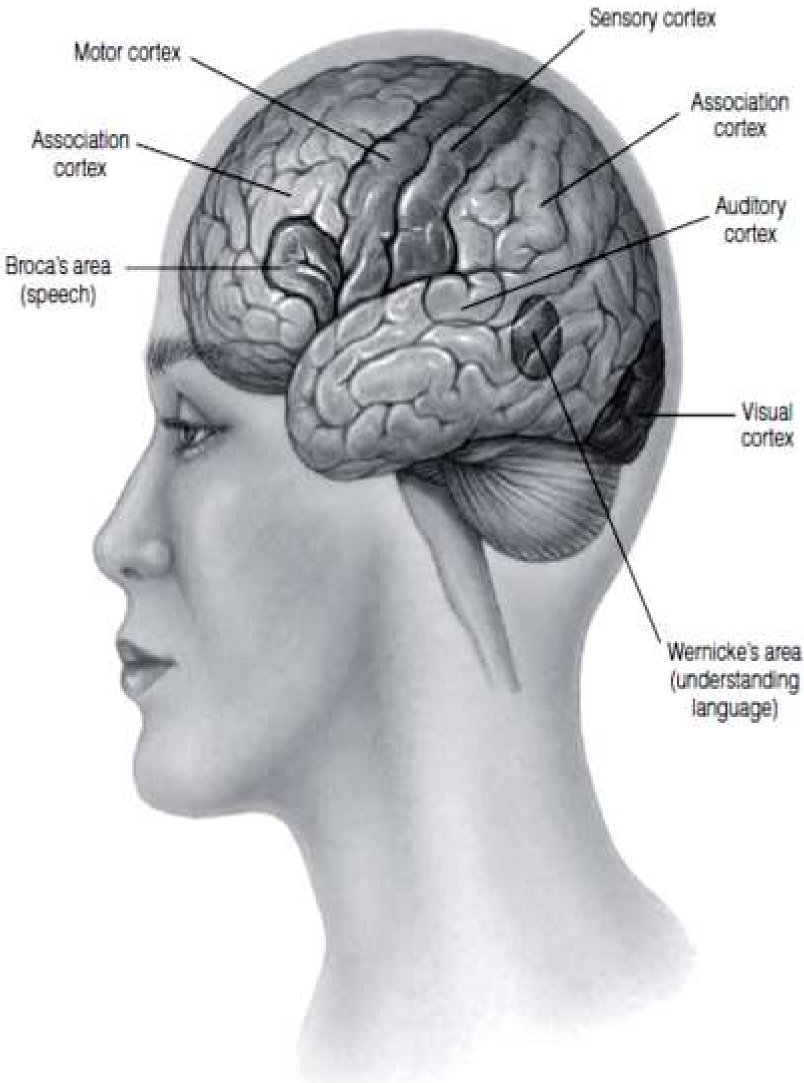


Figure (03): the Functional areas of the Cortex (Sternberg, 2000)

4. Lobes of the Cerebral Hemispheres

For practical purposes, four lobes divide the cerebral hemispheres and cortex into four parts. They are not distinct units. Rather, they are largely arbitrary anatomical regions divided by fissures. Particular functions have been identified with each lobe, but the lobes also interact. The four lobes, named after the bones of the skull lying directly over them are: **the frontal, parietal, temporal,** and **occipital lobes**.

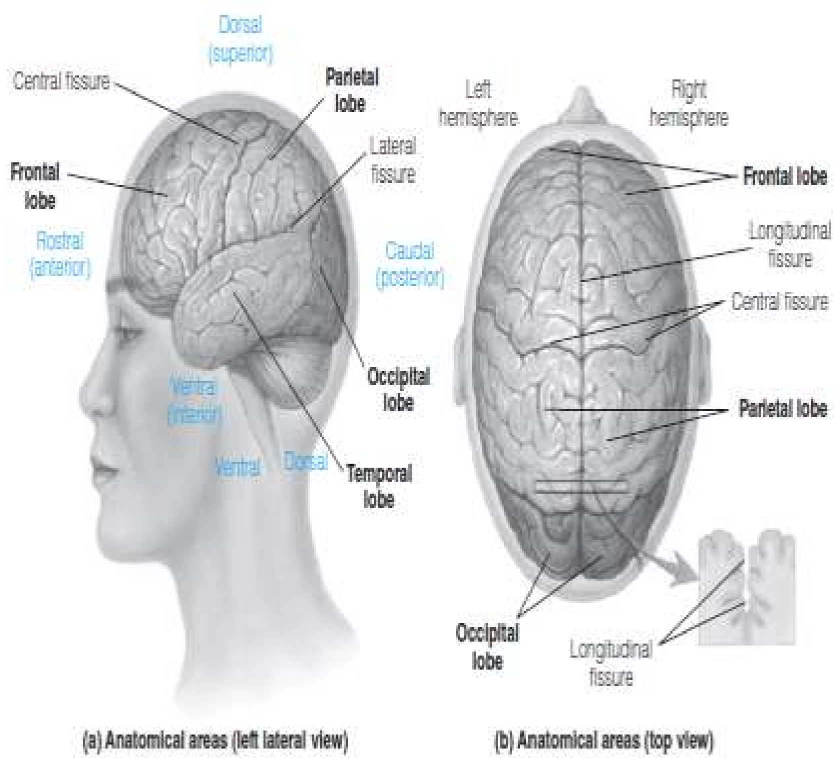


Figure (04): Four Lobes of the Brain (Sternberg, 1998)

4.1.The frontal lobe

It is toward the front of the brain and associated with motor processing and higher thought processes, such as abstract reasoning, problem solving, planning, and judgment (Stuss & Floden, 2003). It tends to be involved when sequences of thoughts or actions are called for. It is critical in producing speech. The prefrontal cortex, the region toward the front of the frontal lobe, is involved in complex motor control and tasks that require integration of information over time (Gazzaniga, Ivry, & Mangun, 2002).

4.2.The parietal lobe

It is at the upper back portion of the brain and associated with somatosensory processing. It receives inputs from the neurons regarding touch, pain, temperature sense, and limb position when you are perceiving space and your relationship to it—how you are situated relative to the space you are occupying (Culham, 2003). The parietal lobe is also involved in consciousness and paying attention. If you are paying attention to what you are reading, your parietal lobe is activated.

4.3.The temporal lobe

It is directly under your temples and associated with auditory processing (Murray, 2003) and comprehending language. It is also involved in your retention of visual memories. For example, if you are trying to keep in memory then your temporal lobe is involved. The temporal lobe also matches new things you see to what you have retained in visual memory.

4.4.The occipital lobe

It is associated with visual processing (De Weerd, 2003b). The occipital lobe contains numerous visual areas, each specialized to analyze specific aspects of a scene, including color, motion, location, and form (Gazzaniga, Ivry, & Mangun, 2002). When you go to pick strawberries, your occipital lobe is involved in helping you find the red strawberries in between the green leaves.

Projection areas are the areas in the lobes in which sensory processing occurs. These areas are referred to as projection areas because the nerves contain sensory information going to (projecting to) the thalamus. It is from here that the sensory information is communicated to the appropriate area in the relevant lobe. Similarly, the projection areas communicate motor information downward through the spinal cord to the appropriate muscles via the peripheral nervous system (PNS).

5. Neuronal Structure and Function

Individual neural cells, called neurons, transmit electrical signals from one location to another in the nervous system (Carlson, 2006). The greatest concentration of neurons is in the neocortex of the brain. The neocortex is the part of the brain associated with complex cognition. This tissue can contain as many as 100,000 neurons per cubic millimeter (Churchland & Sejnowski, 2004). The neurons tend to be arranged in the form of networks, which provide information and feedback to each other within various kinds of information processing (Vogels, Rajan, & Abbott, 2005). Neurons vary in their structure, but almost all neurons have four basic parts, as illustrated in Figure (05).

These include **a soma** (cell body), **dendrites**, **an axon**, and **terminal buttons**.

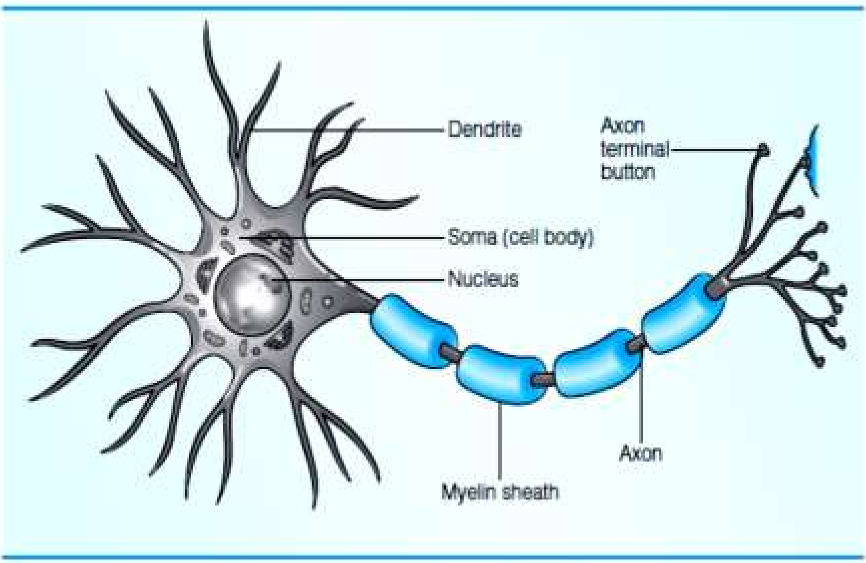


Figure (05): The composition of a Neuron (Sternberg, 1998)

5.1.The soma

It contains the nucleus of the cell (the center portion that performs metabolic and reproductive functions for the cell), is responsible for the life of the neuron and connects the dendrites to the axon.

5.2.The dendrites

They are branchlike structures that receive information from other neurons, and the soma integrates the information. Learning is associated with the formation of new neuronal connections. Hence, it occurs in conjunction with increased complexity or ramification in the branching structure of dendrites in the brain.

5.3.The axon

It is a long, thin tube that extends (and sometimes splits) from the soma and responds to the information, when appropriate, by transmitting an electrochemical signal, which travels to the terminus (end), where the signal can be transmitted to other neurons. Axons are of two basic, roughly equally occurring kinds, distinguished by the presence or absence of myelin. Myelin is a white, fatty substance that surrounds some of the axons of the nervous system, which accounts for some of the whiteness of the white matter of the brain.

- **Myelinated axons** (in that they are surrounded by a myelin sheath): This sheath, which insulates and protects longer axons from electrical interference by other neurons in the area, also speeds up the
- **Unmyelinated axons:** they are smaller and shorter (as well as slower) than the myelinated axons. As a result, they do not need the increased conduction velocity myelin provides for longer axons (Giuliodori & DiCarlo, 2004).

In fact, transmission in myelinated axons can reach 100 meters per second (equal to about 224 miles per hour). Moreover, myelin is not distributed continuously along the axon. It is distributed in segments broken up by **nodes of Ranvier**. **Nodes of Ranvier** are small gaps in the myelin coating along the axon, which serve to increase conduction speed even more by helping to create electrical signals, also called action potentials, which are then conducted down the axon. The degeneration of myelin sheaths along axons in certain nerves is associated with multiple sclerosis, an autoimmune disease. It results in impairments of coordination and balance. In severe cases this disease is fatal.

5.4.The terminal buttons

They are small knobs found at the ends of the branches of an axon that do not directly touch the dendrites of the next neuron. Rather, there is a very small gap, the synapse. The synapse serves as a juncture between the terminal buttons of one or more neurons and the dendrites (or sometimes the soma) of one or more other neurons (Carlson, 2006). Synapses are important in cognition.

6. Brain Disorders

A number of brain disorders can impair cognitive functioning.

6.1.Stroke

Strokes occur when the flow of blood to the brain undergoes a sudden disruption. People who experience stroke typically show marked loss of cognitive functioning. The nature of the loss depends on the area of the brain that is affected by the stroke. There may be paralysis, pain, numbness, a loss of speech, a loss of language comprehension, impairments in thought processes, a loss of movement in parts of the body, or other symptoms.

6.2.Brain Tumors

Brain tumors, also called neoplasms, can affect cognitive functioning in very serious ways. Tumors can occur in either the gray or the white matter of the brain. Tumors of the white matter are more common (Gazzaniga, Ivry, & Mangun, 2009). Following are the most common symptoms of brain tumors.

- Headaches (usually worse in the morning)
- Nausea or vomiting
- Changes in speech, vision, or hearing
- Problems balancing or walking
- Changes in mood, personality, or ability to concentrate

• Problems with memory

• Muscle jerking or twitching (seizures or convulsions)

• Numbness or tingling in the arms or legs

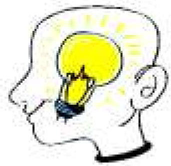
6.3.Head Injuries

Head injuries result from many causes, such as a car accident, contact with a hard object, or a bullet wound. Head injuries are of two types:

- **In closed-head injuries**: the skull remains intact but there is damage to the brain, typically from the mechanical force of a blow to the head. Slamming one's head against a windshield in a car accident might result in such an injury.
- **In open-head injuries**: the skull does not remain intact but rather is penetrated, for example, by a bullet.

Comprehension Check

- ♣ Name some of the major structures in each part of the brain (forebrain, midbrain, and hindbrain) and their functions.
- ♣ What does localization of function mean?
- ♣ Why do researchers believe that the brain exhibits some level of hemispheric specialization?
- ♣ What are the four lobes of the brain and some of the functions associated with them?
- ♣ How do neurons transmit information?



Chapter III: Research Methods in Cognitive Psychology

1. Definition

Researchers employ a variety of research methods. These methods include ***laboratory or other controlled experiments, psychobiological research, self-reports, case studies, naturalistic observation, and computer simulations and artificial intelligence.*** Each of these methods will be discussed in detail in this section. To better understand the specific methods used by cognitive psychologists, one must first grasp the goals of research in cognitive psychology.

2. Goals of Research

Briefly, research goals include:

- Data gathering,
- Data analysis,
- Theory development,
- Hypothesis formulation,
- Hypothesis testing, and perhaps even
- Application to settings outside the research environment.

Often researchers simply seek to gather as much information as possible about a particular phenomenon. They may or may not have preconceived notions regarding what they may find while gathering the data. Their research focuses on describing particular cognitive phenomena, Such as how people recognize faces or how they develop expertise.

Data gathering reflects an empirical aspect of the scientific enterprise. Once there are sufficient data on the cognitive phenomenon of interest, cognitive psychologists use various methods for drawing inferences from the data. Ideally, they use multiple converging types of evidence to support their hypotheses.

Sometimes, just **a quick glance** at the data leads to **intuitive inferences regarding patterns that emerge from those data**. More commonly, however, researchers use various statistical means of analyzing the data.

Data gathering and **statistical analysis** aid researchers in describing cognitive phenomena. No scientific pursuit could get far without such descriptions. However, most cognitive psychologists want to understand more than **the what of cognition**; most also seek to understand **the how and the why of thinking**. That is, researchers seek **ways to explain** cognition as well as **to describe it**. To move beyond descriptions, cognitive psychologists must leap from what is observed directly to what can be inferred regarding observations.

Suppose that we wish to study one particular aspect of cognition. An example would be how people comprehend information in textbooks. We usually start with a theory. **A theory is an organized body of general explanatory principles regarding a phenomenon, usually based on observations.** We seek to test a theory and thereby to see whether it has the power to predict certain aspects of the phenomena with which it deals. In other words, our thought process is**, "If our theory is correct, then whenever x occurs, outcome y should result."**

This process results in the generation of hypotheses, tentative proposals regarding expected empirical consequences of the theory, such as the outcomes of research.

Next, we test our hypotheses through experimentation. Even if particular findings appear to confirm a given hypothesis, the findings must be subjected to statistical analysis to determine **their statistical**

significance. Statistical significance indicates the likelihood that a given set of results would be obtained if only chance factors were in operation.

For example, a statistical significance level of 05 would mean that the likelihood of a given set of data would be a mere 5% if only chance factors were operating. Therefore, the results are not likely to be due merely to chance. Through this method we can decide to retain or reject hypotheses.

Once our hypothetical predictions have been experimentally tested and statistically analyzed, the findings from those experiments may lead to further work. For example, the psychologist may engage in further data gathering, data analysis, theory development, hypothesis formulation, and hypothesis testing. Based on the hypotheses that were retained and/or rejected, the theory may have to be revised.

In addition**, many cognitive psychologists hope to use insights gained from research to help people use cognition in real-life situations.** Some research in cognitive psychology is applied from the start. It seeks to help people improve their lives and the conditions under which they live their lives. Thus, basic research may lead to everyday applications.

For each of these purposes, different research methods offer different advantages and disadvantages.

3. Distinctive Research Methods

Cognitive psychologists use various methods to explore how humans think. These methods include **(a) laboratory or other controlled experiments, (b) psychobiological research, (c) self-reports, (d) case studies, (e) naturalistic observation, and (f)**

computer simulations and artificial intelligence. Each method is explained in the following.

3.1.Experiments on Human Behavior

In controlled experimental designs, an experimenter will usually conduct research in a laboratory setting. The experimenter controls as many aspects of the experimental situation as possible (Sternberg, 1996a). There are basically two kinds of variables in any given experiment.

a) Independent variables: are aspects of an investigation that are individually manipulated, or carefully regulated, by the experimenter, while other aspects of the investigation are held constant (i.e., not subject to variation).

b) Dependent variables: are outcome responses, the values of which depend on how one or more independent variables influence or affect the participants in the experiment.

When you tell some student research participants that they will do very well on a task, but you do not say anything to other participants, the independent variable is the amount of information that the students are given about their expected task performance. The dependent variable is how well both groups actually perform the task—that is, their score on the math test.

When the experimenter manipulates the independent variables, he or she controls for the effects of irrelevant variables and observes the effects on the dependent variables (outcomes). These irrelevant variables that are held constant are called control variables. For example, when you conduct an experiment on people's ability to concentrate when subjected to different kinds of background music, you should make sure that the lighting in the room is always the same, and not sometimes extremely bright and other times dim. The variable of light needs to be held constant (Sternberg, 1996a).

Another type of variable **is the confounding variable**: they are a type of irrelevant variable that has been left uncontrolled in a study. For example, imagine you want to examine the effectiveness of two problem-solving techniques. You train and test one group under the first strategy at 6 A.M. and a second group under the second strategy at 6 P.M.

In this experiment, time of day would be a confounding variable. In other words, time of day may be causing differences in performance that have nothing to do with the problem-solving strategy. Obviously, when conducting research, we must be careful to avoid the influence of confounding variables. (ibid, 1996a).

In implementing the experimental method, experimenters must use **a representative and random sample of the population of interest**

They must exert rigorous control over the experimental conditions so that they know that the observed effects can be attributed to variations in the independent variable and nothing else. For example, in the above mentioned experiment, people's ability to concentrate did not depend on the general lighting conditions in the room, per se, because during a few sessions, the sun shone directly into the eyes of the subjects so that they had trouble seeing (ibid, 1996a).

3.2.Correlational studies

Correlational studies are often the method of choice when researchers do not want to deceive their subjects by using manipulations in an experiment or when they are interested in factors that cannot be manipulated ethically (e.g., lesions in specific parts of the human brain). However, because researchers do not have any control over the experimental conditions, causality cannot be inferred from correlational studies (Sternberg, 1999).

According to Sternberg (1999), a correlation is a description of a relationship. The correlation coefficient describes the strength of the relationship. The closer the coefficient is to 1 (either positive or negative), the stronger the relationship between the variables is. The sign (positive or negative) of the coefficient describes the direction of the relationship.

A positive relationship indicates that as one variable increases (e.g., vocabulary size), another variable also increases (e.g., reading comprehension). A negative relationship indicates that as the measure of one variable increases (e.g., fatigue), the measure of another decreases (e.g., alertness). No correlation that is, when the coefficient is 0 indicates that there is no pattern or relationship in the change of two variables (e.g., intelligence and earlobe length). In this final case, both variables may change, but the variables do not vary together in a consistent pattern.

3.3.Psychobiological Research

Through psychobiological research, Sun (2003) claims that investigators study the relationship between cognitive performance and cerebral events and structures. Various techniques are used in psychobiological research, and They generally fall into three categories:

• **Techniques for studying an individual's brain postmortem** (after the death of an individual), relating the individual's cognitive function prior to death to observable features of the brain;

• **Techniques for studying images showing structures of or activities in the** brain of an individual who is known to have a particular cognitive deficit;

• **Techniques for obtaining information about cerebral processes during the normal performance of a cognitive activity.**

According to Sun (2003), Postmortem studies offered some of the first insights into how specific lesions (areas of injury in the brain) may be associated with particular cognitive deficits. Such studies continue to provide useful insights into how the brain influences cognitive function.

Recent technological developments also increasingly enable researchers to study individuals with known cognitive deficits in vivo (while the individual is alive). The study of individuals with abnormal cognitive functions linked to cerebral damage often enhances our understanding of normal cognitive functions.

Psychobiological researchers also study normal cognitive functioning by studying cerebral activity in animal participants. Researchers often use animals for experiments involving neurosurgical procedures that cannot be performed on humans because such procedures would be difficult, unethical, or impractical.

For example, studies mapping neural activity in the cortex have been conducted on cats and monkeys (e.g., psychobiological research on how the brain responds to visual stimuli) (ibid, 2003)

Can cognitive and cerebral functioning of animals and of abnormal humans be generalized to apply to the cognitive and cerebral functioning of normal humans? Psychobiologists have responded to these questions in various ways. For some kinds of cognitive activity, the available technology permits researchers to study the dynamic cerebral activity of normal human participants during cognitive processing (Sun, 2003).

3.4.Self-Reports, Case Studies, and Naturalistic Observation

Individual experiments and psychobiological studies often focus on precise specification of discrete aspects of cognition across individuals. To obtain richly textured information about how particular individuals think in a broad range of contexts, researchers may use other methods (Von Eckardt, 2005). These methods include:

- **Self-reports** (an individual's own account of cognitive processes);
- **Case studies** (in-depth studies of individuals); and
- **Naturalistic** observation (detailed studies of cognitive performance in everyday situations and nonlaboratory contexts).

3.5.Computer Simulations and Artificial Intelligence

Digital computers played a fundamental role in the emergence of the study of cognitive psychology. There are two kinds of influence:

1) The indirect influence: through models of human cognition based on models of how computers process information.

2) The direct influence: through computer simulations and artificial intelligence.

In computer simulations, researchers program computers to imitate a given human function or process. Examples are performance on particular cognitive tasks (e.g., manipulating objects within three-dimensional space) and performance of particular cognitive processes (e.g., pattern recognition). Some researchers have attempted to create computer models of the entire cognitive architecture of the human mind (Sternberg, 1982).

Consider a computer program that plays chess. There are two entirely different ways to conceptualize how to write such a program.

One is known as brute force: A researcher constructs an algorithm that considers extremely large numbers of moves in a very short time, potentially beating human players simply by virtue of the number of moves it considers and the future potential consequences of these moves. The program would be viewed as successful to the extent that it beat the best humans. This kind of artificial intelligence does not seek to represent how humans function, but done well, it can produce a program that plays chess at the highest possible level.

An alternative approach, simulation, looks at how chess grand masters solve chess problems and then seeks to function the way they do. The program would be successful if it chose, in a sequence of moves in a game, the same moves that the grand master would choose. It is also possible to combine the two approaches, producing a program that generally simulates human performance but can use brute force as necessary to win games.

3.6.Putting It All Together

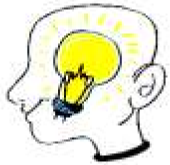
Cognitive psychologists often broaden and deepen their understanding of cognition through research in cognitive science. Cognitive science is a cross-disciplinary field that uses ideas and methods from cognitive psychology, psychobiology, artificial intelligence, philosophy, linguistics, and anthropology (Nickerson, 2005; Von Eckardt, 2005). Cognitive scientists use these ideas and methods to focus on the study of how humans acquire and use knowledge.

Cognitive psychologists also profit from collaborations with other kinds of psychologists. Examples are social psychologists (e.g., in the cross-disciplinary field of social cognition), psychologists who study motivation and emotion, and engineering psychologists (i.e., psychologists who study human-machine interactions), but also clinical psychologists who are interested in psychological disorders. There is also close exchange and collaboration with a number of other related fields.

Psychiatrists are interested in how the brain works and how it influences our thinking, feeling, and reasoning. Anthropologists in turn may explore how reasoning and perception processes differ from one culture to the next. Computer specialists try to develop computer interfaces that are highly efficient, given the way humans perceive and process information. Traffic planners can use information from cognitive psychology to plan and construct traffic situations that result in a maximal overview for traffic participants and therefore, hopefully, fewer accidents (Nickerson, 2005).

Comprehension Check

- What is the meaning of "statistical significance"?
- How do independent and dependent variables differ?
- Why is the experimental method uniquely suited to drawing causal inferences?
- What are some of the advantages and disadvantages of the case-study method?
- How does a theory differ from a hypothesis?



Chapter IV:

Human Perception

1. Definition

Perception is the set of processes by which we recognize, organize, and make sense of stimuli in our environment. The central problem of perception is explaining how we attach meaning to the sensory information we receive? And how we manage to accomplish these feats so rapidly and (usually) without error?

The vast topic of perception can be subdivided into **visual perception, auditory perception, olfactory perception, haptic (touch) perception, and gustatory (taste) perception**. We will concentrate on visual and auditory perception because those two are the kinds of perception psychologists study most.

For the present, we will adopt what might be called the "classic" approach to defining perception. Figure (06) illustrates this approach for visual perception. Out in the real world are objects and events—things to be perceived—such as this book or, trees and shrubs. Each such object is **a distal stimulus.** For a living organism to process information about these stimuli, it must first receive the information through one or more sensory systems—in this example, the visual system.

The reception of information and its registration by a sense organ make up **the proximal stimulus**. In our earlier example, light waves reflect from the trees to your eyes, in particular to a surface at the back of each eye known as the retina. There, an image of the trees, called *the retinal image*, is formed.

This image is two-dimensional, and its size depends on your distance from the window and the objects beyond (the closer you are, the larger the image).

In addition, the image is upside down and is reversed with respect to left and right.

The meaningful interpretation of the proximal stimulus is **the percept**—your interpretation that the stimuli are trees, cars, people, and so forth. From the upside-down, backward, two-dimensional image, you quickly (almost instantaneously) "see" a set of objects you recognize.

Related to perception is a process called **pattern recognition**. This is the recognition of a particular object, event, and so on, as belonging to a class of objects, events, and so on.

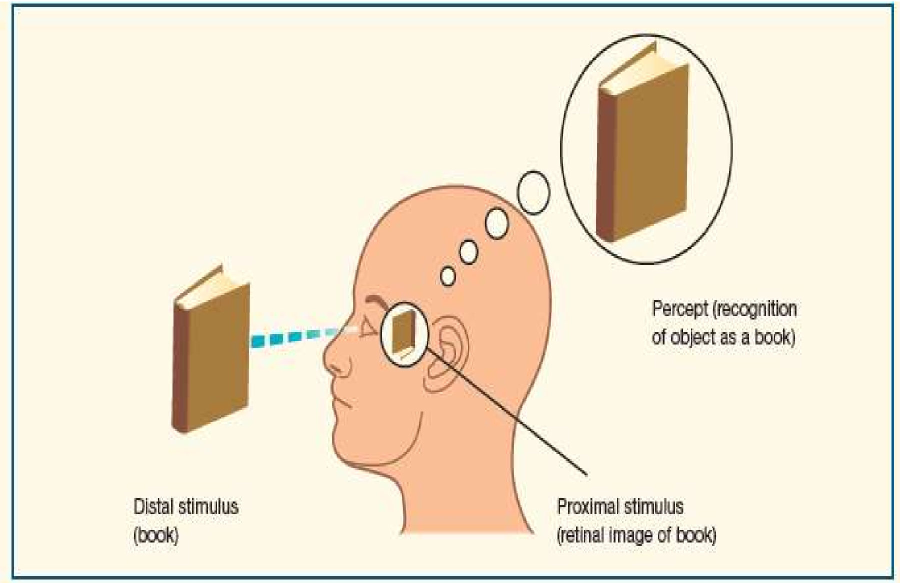


Figure (06): Visual perception (Sternberg, 1998)

2. Approaches to Perception

There are different views on how we perceive the world. These views can be summarized as bottom-up theories and top-down theories. Top-down and bottom-up approaches have been applied to virtually every aspect of cognition. Bottom-up and top-down approaches usually are presented as being in opposition to each other. But to some extent, they deal with different aspects of the same phenomenon. Ultimately, a complete theory of perception will need to encompass both bottom-up and top-down processes.

2.1.BOTTOM-UP PROCESSES

The term *bottom-up* (or *data-driven*) essentially means that the perceiver starts with small bits of information from the environment and combines them in various ways to form a percept (Gibson, 1979). The idea here is that the system works in one direction, starting from the input and proceeding to a final interpretation. In this section, four distinct examples of bottom-up models of perception will be illustrated: direct perception, template theories, feature theories, and recognition-by-components theory.

1) Direct perception: According to Gibson's theory of direct perception, the information in our sensory receptors, including the sensory context, is all we need to perceive anything. As the environment supplies us with all the information we need for perception, this view is sometimes also called ecological perception.

2) Template matching: It holds that patterns are recognized when perceivers match them to stored mental representations (Selfridge & Neisser,1960). In other words, Template theories suggest that we have stored in our minds myriad sets of templates. Templates are highly detailed models for patterns we potentially might recognize. We recognize a pattern by comparing it with our set of templates. We then choose the exact template that perfectly matches what we observe (Selfridge & Neisser, 1960). We see examples of template matching in our everyday lives. Fingerprints are matched in this way.

3) Feature-Matching Theories: Yet another alternative explanation of pattern and form perception may be found in feature-matching theories. According to these theories, we attempt to match features of a pattern to features stored in memory, rather than to match a whole pattern to a template or a prototype (Stankiewicz, 2003).

4) Recognition-by-Components Theory: it is about how do we form stable 3-D mental representations of objects? The recognition by-components theory explains our ability to perceive 3-D objects with the help of simple geometric shapes.

Irving Biederman (1987) suggested that we achieve this by manipulating a number of simple 3-D geometric shapes called geons (for geometrical ions).

They include objects such as bricks, cylinders, wedges, cones, and their curved axis counterparts. Biederman's RBC theory explains how we may recognize general instances of chairs, lamps, and faces, but it does not adequately explain how we recognize particular chairs or particular faces.

Another problem with Biederman's approach, and the bottom-up approach in general, is how to account for the effects of prior expectations and environmental context on some phenomena of pattern perception.

2.2.TOP- DOWN PROCESSES

In contrast to the bottom-up approach to perception is the top-down, constructive approach (Bruner, 1957; Gregory, 1980). In constructive perception, the perceiver builds (constructs) a cognitive understanding (perception) of a stimulus.

The concepts of the perceiver and his or her cognitive processes influence what he or she sees.

Top-down, or conceptually driven, processes are directed by expectations derived from context or past learning or both.

All bottom-up models share a number of problems in explaining how viewers "make meaning" of the stimuli they perceive.

Top-down, or conceptually driven, processes are those directed by expectations derived from context or past learning or both.

According to constructivists, during perception we quickly form and test various hypotheses regarding percepts.

The percepts are based on three things:

- What we sense (the sensory data),
- What we know (knowledge stored in memory), and
- What we can infer (using high-level cognitive processes).

According to constructivists, we usually make the correct attributions regarding our visual sensations.

The reason is that we perform unconscious inference, the process by which we unconsciously assimilate information from a number of sources to create a perception (Snow & Mattingley, 2003).

In other words, using more than one source of information, we make judgments that we are not even aware of making.

3. Perception of Objects and Forms

There are two common positions regarding the perception of objects and forms.

3.1.Viewer-centered representation

In this representation, the individual stores the way the object looks to him or her. Thus, what matters is the appearance of the object to the viewer, not the actual structure of the object. The shape of the object changes, depending on the angle from which we look at it. A number of views of the object are stored, and when we try to recognize an object, we have to rotate that object in our mind until it fits one of the stored images.

3.2.Object-centered representation

In this representation, the individual stores a representation of the object, independent of its appearance to the viewer. In this case, the shape of the object will stay stable across different orientations (McMullen & Farah, 1991). This stability can be achieved by means of establishing the major and minor axes of the object, which then serve as a basis for defining further properties of the object.

4. The Perception of Groups—Gestalt Laws

When stimuli occur close to one another in space and in time, they may group perceptually into coherent, salient patterns or wholes. Such Gestalts, as they are called, abound in our perceptual world, as when leaves and branches cluster into trees, and when trees merge into forests; when eyes, ears, noses and mouths configure into faces; when musical notes coalesce into chords and melodies; and when countless dots or pixels blend into a photograph.

4.1.Gestalt principles of perceptual organization

- **The principle of proximity, or nearness:** Look at Figure 7.(A). Notice that you tend to perceive this as a set of rows rather than as a set of columns. This is because the elements within rows are closer than the elements within columns. Following the principle of proximity, we group together things that are nearer to each other.
- **The principle of similarity:** Grouping together those elements that are similar. Notice that you perceive this display as formed in columns (rather than rows) .7(B).
- **The principle of good continuation**, depicted in Figure 7. (C), states that we group together objects whose contours form a continuous straight or curved line. Thus we typically perceive Figure 7. (C) as two intersecting curved lines and not as other logically possible elements, such as those shown in Figure 7. (D).
- **The principle of closure**, when we look at subjective contour, Figure 7. (E) illustrates this principle more exactly. Note that we perceive this display as a rectangle, mentally filling in the gap to see a closed, complete, whole figure.
- **The principle of common fate**, is difficult to illustrate in a static drawing. The idea is that elements that move together will be grouped together, as depicted in Figure 7. (F).

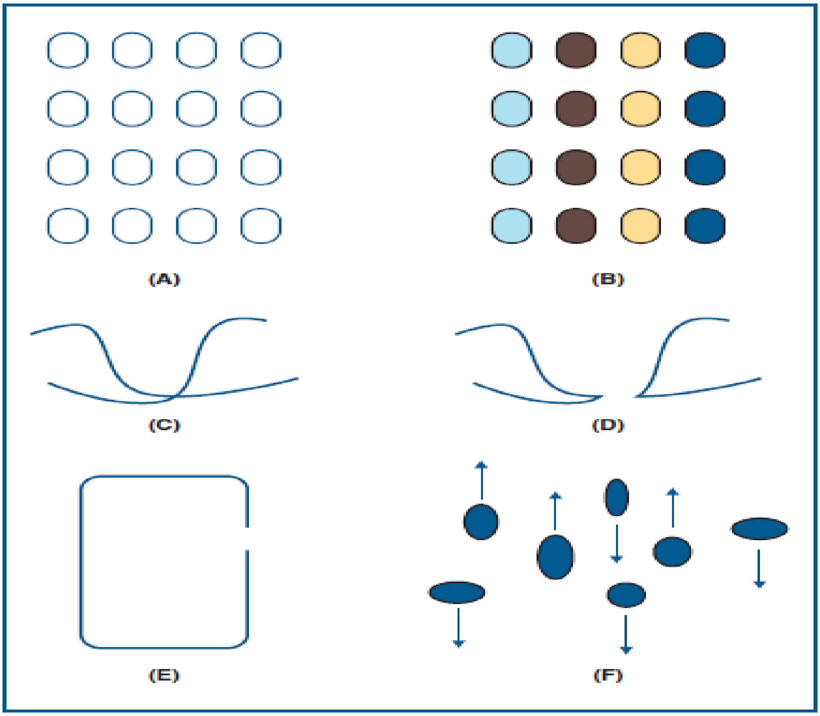


Figure 7: Gestalt principles of perceptual organization: (A) the principle of proximity; (B) the principle of similarity; (C) and (D) the principle of good continuation; (E) the principle of closure; and (F) the principle of common fate (Sternberg, 1998)

The Gestalt principles provide valuable descriptive insights into form and pattern perception. But they offer few or no explanations of these phenomena. To understand how or why we perceive forms and patterns, we need to consider explanatory theories of perception.

5. Perception deficits

Cognitive psychologists learn a great deal about normal perceptual processes by studying perception in normal participants. However, they also often gain understanding of perception by studying people whose perceptual processes differ from the norm (Farah, 1990).

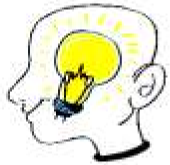
What happens when people with normal visual sensations cannot perceive visual stimuli? **Agnosias**, which are usually associated with brain lesions, are deficits of form and pattern perception. They cause afflicted people to be insufficiently able to recognize objects that are in their visual fields, despite normal sensory abilities.

People who suffer from **visual-object agnosia** can sense all parts of the visual field. But the objects they see do not mean anything to them. Individuals with **simultagnosia** are unable to pay attention to more than one object at a time. People with **spatial agnosia** have severe difficulty in comprehending and handling the relationship between their bodies and the spatial configurations of the world around them.

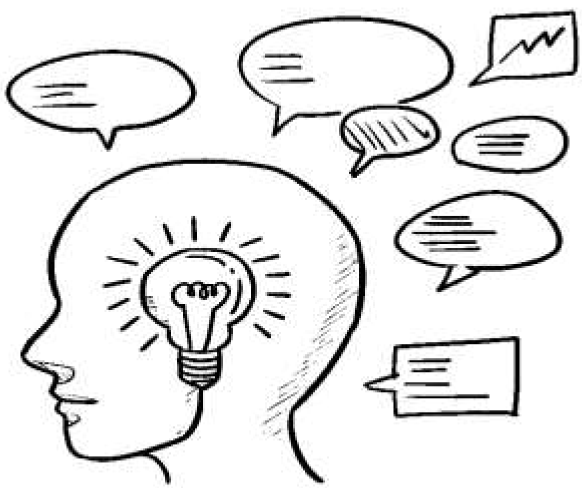
People with **prosopagnosia** have severe impairment in their ability to recognize human faces, including their own. **Color blindness** is another type of perceptual deficit.

Comprehension Check

- ♣ What is the difference between the distal and the perceptual object?
- ♣ What are some of the major parts of the eye and what are their functions?
- ♣ What are the major Gestalt principles?
- ♣ What is the "recognition by components" theory?
- ♣ What is the difference between top-down and bottom-up theories of perception?
- ♣ What is the difference between viewer-centered and object-centered perception?



Chapter V: Attention and Consciousness



1. Definition

Attention is the means by which we actively process a limited amount of information from the enormous amount of information available through our senses, our stored memories, and our other cognitive processes (De Weerd, 2003a). It includes both conscious and unconscious processes. In many cases, conscious processes are relatively easy to study. Unconscious processes are harder to study, simply because you are not conscious of them (Jacoby, Lindsay, & Toth, 1992).

Attention allows us to use our limited mental resources judiciously. By dimming the lights on many stimuli from outside (sensations) and inside (thoughts and memories), we can highlight the stimuli that interest us. This heightened focus increases the likelihood that we can respond speedily and accurately to interesting stimuli.

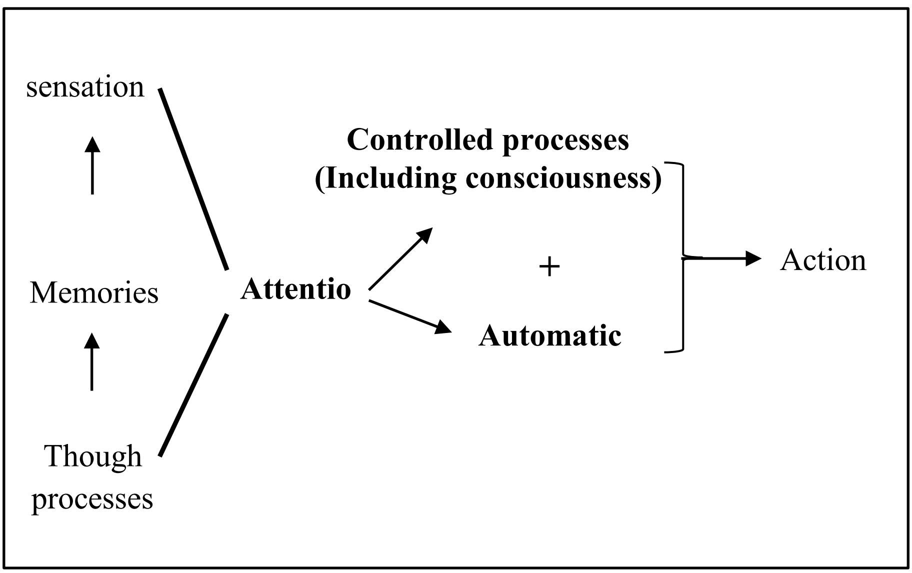


Figure (08): How does attention work? (Sternberg, 1998)

2. Kinds of attention

There are the four main functions of attention:

2.1.Signal detection and vigilance

We try to detect the appearance of a particular stimulus. Air traffic controllers, for example, keep an eye on all traffic near and over the airport. For example, we may try to detect unwelcome sights or sounds; or following an earthquake, we may be wary of the smell of leaking gas or of smoke.

2.2.Search

We try to find a signal amidst distracters, for example, when we are looking for our lost cell phone on an autumn leaf-filled hiking path. For example, If we detect smoke (as a result of our vigilance), we may engage in an active search for the source of the smoke. In addition, some of us are often in search of missing keys, sunglasses, and other objects.

2.3.Selective attention

We choose to attend to some stimuli and ignore others, as when we are involved in a conversation at a party. For example, we may pay attention to reading a textbook or to listening to a lecture while ignoring such stimuli as a nearby radio or television or latecomers to the lecture.

2.4.Divided attention

We prudently allocate our available attentional resources to coordinate our performance of more than one task at a time, as when we are cooking and engaged in a phone conversation at the same time. For example, experienced drivers easily can talk while driving under most circumstances, but if another vehicle seems to be swerving toward their car, they quickly switch all their attention away from talking and toward driving.

3. Factors that Influence our Ability to Pay Attention

There are many variables that have an impact on our ability to concentrate and pay attention. Here are some of them:

3.1.Anxiety

Being anxious, either by nature (trait-based anxiety) or by situation (state-based anxiety), places constraints on attention (Reinholdt-Dunne et al., 2009).

3.2.Arousal

Your overall state of arousal affects attention as well. You may be tired, drowsy, or drugged, which may limit attention. Being excited sometimes enhances attention (MacLean et al., 2009).

3.3.Task difficulty

If you are working on a task that is very difficult or novel for you, you'll need more attentional resources than when you work on an easy or highly familiar task. Task difficulty particularly influences performance during divided attention.

3.4.Skills

The more practiced and skilled you are in performing a task, the more your attention is enhanced (Spelke, Hirst, & Neisser, 1976).

4. Habituation and Adaptation

Responses involving physiological adaptation take place mostly in our sense organs, whereas responses involving cognitive habituation take place mostly in our brains (and relate to learning).

4.1.Habituation

It involves our becoming accustomed to a stimulus so that we gradually pay less and less attention to it. The counterpart to habituation is **dishabituation.** In **dishabituation,** a change in a familiar stimulus prompts us to start noticing the stimulus again. Both processes occur automatically. The processes involve no conscious effort. The relative stability and familiarity of the stimulus govern these processes. Any aspects of the stimulus that seem different or novel (unfamiliar) either prompt dishabituation or make habituation less likely to occur in the first place. For example, suppose that a radio is playing instrumental music while you study your cognitive psychology textbook.

At first the sound might distract you. But after a while you become habituated to the sound and scarcely notice it. If the loudness of the noise were suddenly to change drastically, however, immediately you would dishabituate to it. The once familiar sound to which you had been habituated would become unfamiliar. It thus would enter your awareness (Castellucci & Kandel, 1976).

4.2.Sensory adaptation

It is a lessening of attention to a stimulus that is not subject to conscious control. It occurs directly in the sense organ, not in the brain. We can exert some conscious control over whether we notice something to which we have become habituated, but we have no conscious control over sensory adaptation. For example, we cannot consciously force ourselves to smell an odor to which our senses have become adapted. Nor can we consciously force our pupils to adapt—or not adapt—to differing degrees of brightness or darkness.

In contrast, if someone asked us, "Who's the lead guitarist in that song?" we can once again notice background music (Schneider & Shiffrin, 1977).

5. Automatic and Controlled Processes

There is probably a continuum of cognitive processes, from fully controlled processes to fully automatic ones.

5.1.Automatic processes

For the most part, they are performed without conscious awareness. Nevertheless, you may be aware that you are performing them. They demand little or no effort or even intention. Multiple automatic processes may occur at once, or at least very quickly, and in no particular sequence. Thus, they are termed parallel processes (Palmeri, 2003). Three attributes characterize automatic processes (Posner & Snyder, 1975).

- **First,** they are concealed from consciousness.
- **Second**, they are unintentional.
- **Third,** they consume few attentional resources.

5.2.Controlled processes

They are accessible to conscious control and even require it. Such processes are performed serially, for example, when you want to compute the total cost of a trip you are about to book online. In other words, controlled processes occur sequentially, one-step at a time.

They take a relatively long time to execute, at least as compared with automatic processes.

The following table summarizes the characteristics of controlled versus automatic processes.

<table>
<tr><th>Characteristics</th><th>Controlled Processes</th><th>Automatic Processes</th></tr>
<tr><td>Amount of intentional effort</td><td>Require intentional effort</td><td>Require little or no intention or effort (and intentional effort may even be required to avoid automatic behavior)</td></tr>
<tr><td>Degree of conscious awareness</td><td>Requite full Conscious awareness</td><td>Generally occur outside of conscious awareness, although some automatic processes may be available to consciousness.</td></tr>
<tr><td>Type of processing</td><td>Performed serially (one step al a time)</td><td>Performed by parallel processing (i.e, with many operations occurring simultaneously or al least in no particular sequential order)</td></tr>
<tr><td>Speed of processing</td><td>Relatively time-consuming execution, as compared with automatic processes</td><td>Relatively fast</td></tr>
<tr><td>Relative novelty of tasks</td><td>Novel and unpracticed tasks or tasks with many variable features</td><td>Familiar and highly practiced tasks, with largely stable task characteristics</td></tr>
<tr><td>Level of processing</td><td>Relatively high levels of cognitive processing (requiring analysis or synthesis)</td><td>Relatively low levels of cognitive processing (minimal analysis or synthesis)</td></tr>
<tr><td>Difficulty of tasks</td><td>Usually difficult tasks</td><td>Usually relatively easy tasks, but even relatively complex tasks may be automatized, given sufficient practice.</td></tr>
<tr><td>Process of acquisition</td><td colspan="2">With sufficient practice, many routine and relatively stable procedures may become partly or even wholly automatic, naturally, the amount of practice required for automatizafion increases dramatically for highly complex tasks.</td></tr>
</table>

Table (02): Controlled versus Automatic Processes (Sternberg, 1998)

6. Consciousness

At one time, psychologists believed that attention was the same thing as consciousness. Now, however, they acknowledge that some active attentional processing of sensory and of remembered information proceeds without our conscious awareness (Bahrami et al., 2008). For example, writing your name requires little conscious awareness. You may write it while consciously engaged in other activities. In contrast, writing a name that you have never encountered requires attention to the sequence of letters. Consciousness includes both the feeling of awareness and the content of awareness, some of which may be under the focus of attention (Bourguignon, 2000; Taylor, 2002).

Conscious attention serves three purposes for cognition.

1) It helps in monitoring our interactions with the environment. Through such monitoring, we maintain our awareness of how well we are adapting to the situation in which we find ourselves.

2) It assists us in linking our past (memories) and our present (sensations) to give us a sense of continuity of experience. Such continuity may even serve as the basis for personal identity.

3) It helps us in controlling and planning for our future actions. We can do so based on the information from monitoring and from the links between past memories and present sensations.

7. Deficits in Perception

Clearly, cognitive psychologists learn a great deal about normal perceptual processes by studying perception in normal participants. However, we also often gain understanding of perception by studying people whose perceptual processes differ from the norm (Farah, 1990). In the following sections, we will consider two examples of failing attention: attention deficit hyperactivity disorder and change/inattentional blindness.

7.1.Attention Deficit Hyperactivity Disorder (ADHD)

People with attention deficit hyperactivity disorder **(ADHD)** have difficulties in focusing their attention in ways that enable them to adapt in optimal ways to their environment (Swanson et al., 2003). The three primary symptoms of ADHD are: inattention, hyperactivity (i.e., levels of activity that exceed what is normally shown by children of a given age), and impulsiveness.

Children with the inattentive type of ADHD show several distinctive symptoms:

- They are easily distracted by irrelevant sights and sounds.
- They often fail to pay attention to details.
- They are susceptible to making careless mistakes in their work.
- They often fail to read instructions completely or carefully.
- They are susceptible to forgetting or losing things they need for tasks, such as pencils or books.
- They tend to jump from one incomplete task to another.

7.2. Change Blindness and Inattentional Blindness

It is the inability to detect changes in objects or scenes that are being viewed (Galpin et al., 2009). Closely related to change blindness is inattentional blindness, which is a phenomenon in which people are not able to see things that are actually there (Bressan & Pizzighello, 2008).

7.3. Spatial Neglect—One Half of the World Goes Amiss

It is an attentional dysfunction in which participants ignore the half of their visual field that is contralateral to (on the opposite side of) the hemisphere of the brain that has a lesion. It is a result mainly of unilateral lesions in the parietal and frontal lobes, most often in the right hemisphere (Hillis, 2005).

Comprehension Check

- ♣ Why is habituation important?
- ♣ How do we become habituated to stimuli?
- ♣ How do mental processes become automated?
- ♣ What is priming and how can it be studied?
- ♣ What symptoms do patients have who exhibit blindsight?

Chapter VI:

Human Memory

Part I: Introduction to Human Memory

1. Definition

Memory is defined as the faculty of the mind by which information is encoded, stored, and retrieved (Atkinson & Shiffrin, 1968). Memory is vital to experience. Without memory, we are not us. If we could not remember past events, we could not learn or develop language, relationships, nor personal identity (Eysenck, 2012).

2. Components of memory

Often memory is understood as an informational processing system with explicit and implicit functioning that is made up of a sensory processor, short-term (or working) memory, and long-term memory (Baddely, 2007).

2.1.Sensory memory

Sensory memory represents the initial stage of stimuli perception. It is associated with the senses, and there seems to be a separate section for each type of sensual perception, each with its own limitations and devices. Obviously, stimuli that are not sensed cannot be further processed and will never become part of the memory store. This is not to say that only stimuli that are consciously perceived are stored; on the contrary, everyone takes in and perceives stimuli almost continuously.

It is hypothesized, though, that perceptions that are not transferred into a higher stage will not be incorporated into memory that can be recalled.

2.1.1. Types of Sensory memory

There are three types of sensory memories:

1) **Iconic memory** is a fast decaying store of visual information; a type of sensory memory that briefly stores an image which has been perceived for a small duration.

2) **Echoic memory** is a fast decaying store of auditory information, another type of sensory memory that briefly stores sounds that have been perceived for short durations.

3) **Haptic memory** is a type of sensory memory that represents a database for touch stimuli.

The transfer of new information quickly to the next stage of processing is of critical importance, and sensory memory acts as a portal for all information that is to become part of memory. This stage of memory is temporally limited which means that information stored here begins to decay rapidly if not transferred to the next stage. This occurs in as little as ½ second for visual stimuli and three seconds for auditory stimuli. There are many ways to ensure transfer and many methods for facilitating that transfer.

To this end, attention and automaticity are the two major influences on sensory memory, and much work has been done to understand the impact of each on information processing.

2.2.Short-term memory

The second stage of information processing is the working or short-term memory. This stage is often viewed as active or conscious memory because it is the part of memory that is being actively processed while new information is being taken in. Short-term memory has a very limited capacity and unrehearsed information will begin to be lost from it within 15-30 seconds if other action is not taken.

There are two main ways that are effective in processing information while it is in short-term memory. Rote or maintenance rehearsal is the first but less desirable of these methods. This type of rehearsal is intended only to keep information until it can be processed further. It consists mainly of some sort of repetition of the new information, and if it is not processed further will be lost.

In fact, studies on the limitations of working memory have revealed a specific number of units that the mind can process at any given time, and it is now generally accepted that 5 +2 is the maximum number of stimuli that can be processed at once.

There are several types of activities that one can perform to encode new information, but the importance of encoding cannot be overstated. Maintenance rehearsal schemes can be employed to keep information in short-term memory, but more complex elaboration is necessary to make the transfer to long-term memory.

It is absolutely necessary for new information to somehow be incorporated into the memory structure in order for it to be retained.

There are many suggested models for encoding, but there are basically three ways in which retention occurs. A stimulus can be an almost exact match with existing structures in which case it would be simply added to the mental representation and no change would be made to the structure except its addition.

If the new stimulus does not exactly match the existing structure, the structure itself would be adapted to allow for additional characteristics or definitions in which case there would be a fundamental change to the existing structure, which would broaden the defining structures.

Finally, if the new stimulus were vastly different from any existing structure, a totally new one would be created in memory. This new structure could in some way be linked to relevant structures, but it would stand alone as a new unit.

At any rate, the incoming information must be acted on and through existing structures and incorporated into those systems in some way for acquisition to occur. The processing of this new stimulus takes place inshort-term memory, and the body with which the information is worked is the long-term memory.

2.3.Long-term memory

As discussed with short-term memory, long-term memory houses all previous perceptions, knowledge, and information learned by an individual, but it is not a static file system that is used only for information retrieval.

Abbot (2002) suggests that long-term memory "is that more permanent store in which information can reside in a dormant state – out of mind and unused – until you fetch it back into consciousness" (p. 1). Inorder to incorporate new information, long-term memory must be in communication with short-term memory and must be dynamic.

There are several categories of long-term memory, and there are many suggestions as to how memory units are represented in the mind.

While it seems that it might be sufficient to understand simply that there are individual units and structures that exist in long-term memory, the specific way or ways that information is stored offers extremely important information.

If the knowledge unit is pictorial rather than verbal, for example, it would seem to make sense that images would be more easily and readily stored in memory. If the reverse were true, information should be presented in verbal constructs.

This oversimplifies the problem, but it is this question that is at the core of the controversy over memory storage structures. There are two divisions at issue in the discussion of long-term memory: the types of long-term memory and the type of knowledge unit stored in long-term memory.

2.3.1.Organizations of long-term memory

Today cognitive psychologists believe that there are at least different types of information stored in long-term memory. Each of the memory structures is distinct and serves a different operational function. However, it is evident that some type of very specialized categorization system exists within the human mind. One of the first to make this idea explicit was Bruner (as cited in Anderson, 1996). "Based upon the idea of categorization, Bruner's theory states 'To perceive is to categorize, to conceptualize is to categorize, to learn is to form categories, to make decisions is to categorize" (p. 1).

Tulving (1972) was the first to distinguish between **episodic** and **semantic** memory, and all discussions recognize these two distinct types. Most researchers now combine these two in a broader category labeled declarative. Other researchers have identified additional organizational types. For example, Abbott lists declarative and procedural while Huitt (2000), citing the work of Paivio (1969) adds imagery to this list. However, Pylyshyn (2006) states that imagery is not a distinct organizational structure, but follows the rules that apply to semantic and episodic memory.

Abbott (2002) defines declarative memory in similar terms. He refers to declarative memory as that which can be talked about or verbalized. It is, then, the sum of stored information that can be readily retrieved and put into words inconscious thought and sharing.

As previously stated, declarative memory can be subdivided into both semantic and episodic memories. These two subtypes are radically different although they can each be fairly easily recalled and manipulated. Episodic memory's store is centered on personal experience and specific events.

It is entirely circumstantial and it is not generally used for the processing of new information except as a sort of backdrop. "Episodic memories are those which give a subject the sense of remembering the actual situation, or event" (Eliasmith, 2001). This type of memory is somewhat like a personal video of a specific significant day or event, and its parts are not easily disseminated to characteristics or concepts.

Semantic memory, in contrast, deals with general, abstract information and can be recalled independently of how it was learned. It is semantic memory that is the central focus of most current study because it houses the concepts, strategies and other structures that are typically used for encoding new information. Procedural memory can be thought of as "how to" knowledge (Huitt, 2000 p. 4).

It is the type of long-term memory sometimes associated with information that has reached a state of automaticity, but it not limited to this. This type of memory is defined in terms of learned skills and the ability to recall instruction-like memory. Paivio (1969) describes imagery as the memory structure for collecting and storing information related to pictures.

It captures information much like a photograph and can be extremely useful for context and visual presentation of information.

3. Models of Memory

Models of memory provide abstract representations of how memory is believed to work. Below are the multi-store model, and the working memory model.

3.1.The multi-store model

The multi-store model (also known as Atkinson–Shiffrin memory model) was first described in 1968 by Atkinson and Shiffrin. The multi-store model has been criticized for being too simplistic. For instance, long-term memory is believed to be actually made up of multiple subcomponents, such as episodic and procedural memory.

It also proposes that rehearsal is the only mechanism by which information eventually reaches long-term storage, but evidence shows us capable of remembering things without rehearsal. The model also shows all the memory stores as being a single unit whereas research into this shows differently. For example, short-term memory can be broken up into different units such as visual information and acoustic information.

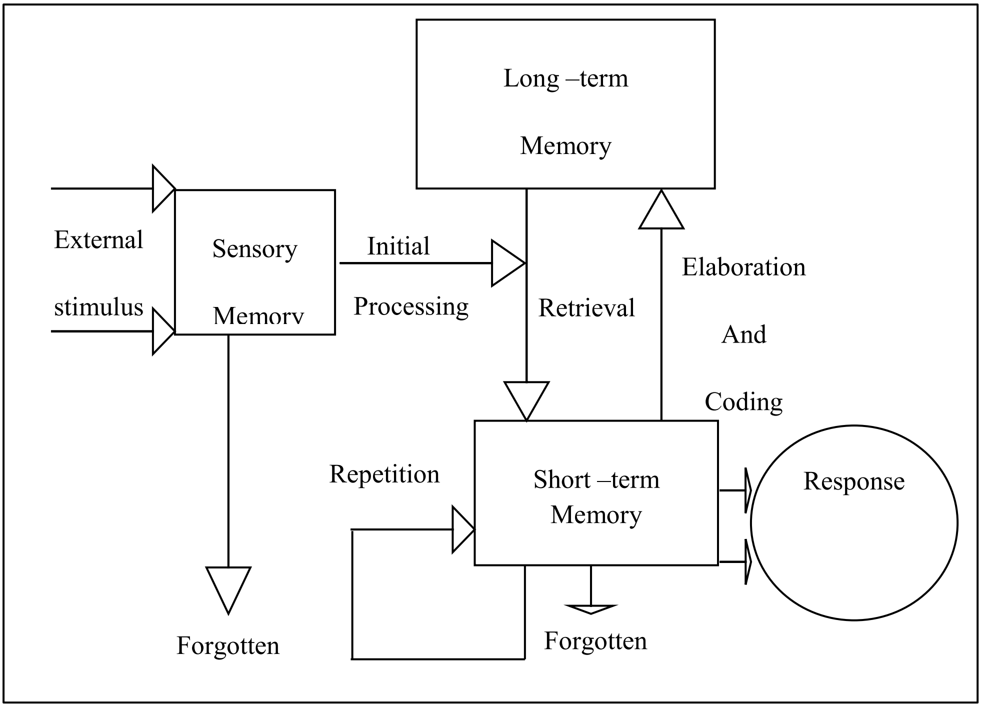


Figure (09): The multi-store model of memory (Atkinson & Shiffrin's 'multi-store' memory model, 1968)

3.2.The working memory model

In this model, working memory consists of three basic stores: the central executive, the phonological loop and the visuo-spatial sketchpad. The central executive essentially acts as an attention sensory store.

It channels information to the three component processes: the phonological loop, the visuo-spatial sketchpad, and the episodic buffer. The phonological loop stores auditory information by silently rehearsing sounds or words in a continuous loop: the articulatory process (for example the repetition of a telephone number over and over again). A short list of data is easier to remember.

The visuospatial sketchpad stores visual and spatial information. It is engaged when performing spatial tasks (such as judging distances) or visual ones (such as counting the windows on a house or imagining images). The episodic buffer is dedicated to linking information across domains to form integrated units of visual, spatial, and verbal information and chronological ordering (e.g., the memory of a story or a movie scene). The episodic buffer is also assumed to have links to long-term memory and semantical meaning (Baddeley, 1975).

The working memory model explains many practical observations, such as why it is easier to do two different tasks (one verbal and one visual) than two similar tasks (e.g., two visual), and the aforementioned word-length effect. However, the concept of a central executive as noted here has been criticised as inadequate and vague. Working memory is also the premise for what allows us to do everyday activities involving thought. It is the section of memory where we carry out thought processes and use them to learn and reason about topics.

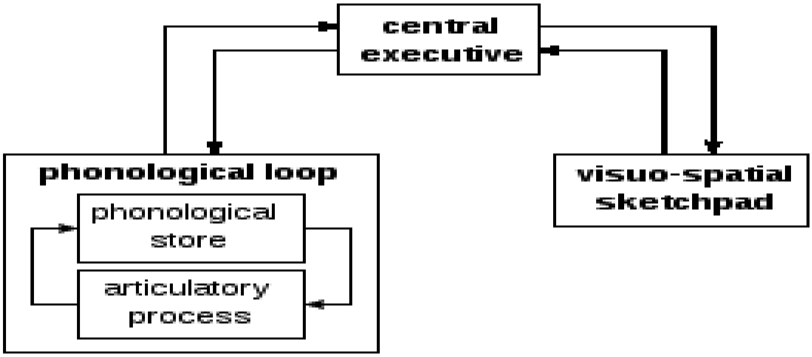


Figure (10): The working memory model (Baddeley, 1974)

Part II: Memory Processes

1. Encoding and Transfer of Information

Before information can be stored in memory, it first needs to be encoded for storage. Even if the information is held in our short-term memory, it is not always transferred to our long-term memory.

So in order to remember events and facts over a long period of time, we need **to encode** and subsequently **transfer** them from **short-term** to **long-term storage**.

1.1.Forms of Encoding

1.1.1. Short-Term Storage

Encoding of information in short-term memory appears to be largely, although not exclusively, acoustic in form. Information in short-term memory is susceptible to acoustic confusability—that is, errors based on sounds of words. But there is some visual and semantic encoding of information in short-term memory.

2.1.1. Long-Term Storage

Information in long-term memory appears to be encoded primarily in a semantic form. Thus, confusions tend to be in terms of meanings rather than in terms of the sounds of words. In addition, some evidence points to the existence of visual encoding, as well as of acoustic encoding, in long-term storage.

2. Transfer of Information from Short-Term Memory to Long-Term Memory

The means of moving information depends on whether the information involves declarative or nondeclarative memory. Some forms of nondeclarative memory are highly volatile and decay quickly. Other nondeclarative forms are maintained more readily, particularly as a result of repeated practice (of procedures) or repeated conditioning (of responses).

Entrance into long-term declarative memory may occur through a variety of processes:

- Attending to information to comprehend it
- Consolidating by making connections or associations between the new information and what we already know and understand. In consolidation, we may use various metamemory strategies to preserve or enhance the integrity of memories. Metamemory strategies involve reflecting on our own memory processes with a view to improving our memory.
- Reconsolidation has the same effect that consolidation does, but it is completed on previously encoded information. Reconsolidation does not necessarily occur with each memory we recall but does seem to occur with relatively newly consolidated material (Walker et al., 2003).

Two key problems are faced when information is transferred from short-term memory to long-term memory**: interference and decay** (Berman et al., 2009).

- **Interference**: it occurs when competing information interferes with our storing information,
- **Decay:** it occurs when information is forgotten facts just because time passes,

2.1.Rehearsal

It is the repeated recitation of an item. The effects of such rehearsal are termed practice effects. Rehearsal may be **overt**, in which case it is usually aloud and obvious to anyone watching. Or it may be **covert**, in which case it is silent and hidden (Tulving, 1962). There are two types of rehearsal:

2.1.1. Elaborative Rehearsal

In elaborative rehearsal, the individual somehow elaborates the items to be remembered. Such rehearsal makes the items either more meaningfully integrated into what the person already knows or more meaningfully connected to one another and therefore more memorable.

2.1.2. Maintenance Rehearsal

In maintenance rehearsal, the individual simply repetitiously rehearses the items to be repeated. Such rehearsal temporarily maintains information in short-term memory without transferring the information to long-term memory.

2.2.Mnemonic devices

They are specific techniques used to help memorize lists of words (Best, 2003): categorical clustering, acronyms, acrostics, interactive imagery among items, pegwords, and the method of loci—can help you to memorize lists of words and vocabulary items:

• **In categorical clustering**, organize a list of items into a set of categories.

• **In interactive images**, imagine (as vividly as possible) the objects represented by

words you have to remember as if the objects are interacting with each other in some active way.

• **In the pegword system**, associate each word with a word on a previously memorized list and form an interactive image between the two words.

• **In the method of loci**, visualize walking around an area with distinctive, wellknown landmarks and link the various landmarks to specific items to be remembered.

• **In using acronyms,** devise a word or expression in which each of its letters stands for a certain other word or concept.

• **In using acrostics,** form a sentence, rather than a single word, to help one remember new words.

• **In using the keyword system**, create an interactive image that links the sound and meaning of a foreign word with the sound and meaning of a familiar word.

3. Retrieval

Are items retrieved all at once (parallel processing) or sequentially (serial processing)? If retrieved serially, the question then arises: Are all items retrieved, regardless of the task (exhaustive retrieval), or does retrieval stop as soon as an item seems to accomplish the task (self-terminating retrieval)?

In fact, studying retrieval from long-term memory is difficult due to problems of differentiating retrieval from other memory processes. It also is difficult to differentiate accessibility from availability. Availability is the presence of information stored in long-term memory. Accessibility is the degree to which we can gain access to the available information.

Retrieval of information from short-term memory appears to be in the form of serial exhaustive processing. This implies that a person always sequentially checks all information on a list.

Nevertheless, some data may be interpreted as allowing for the possibility of self-terminating serial processing and even of parallel processing (Tulving & Pearlstone, 1966).

4. Memory Distortions

People have tendencies to distort their memories. For example, just saying something has happened to you makes you more likely to think it really happened. This is true whether the event happened or not. These distortions tend to occur in seven specific ways, which Schacter (2001) refers to as the "seven sins of memory." Here are Schacter's "seven sins":

- **Transience:** Memory fades quickly. For example, although most people know that O. J. Simpson was acquitted of criminal charges in the murder of his wife, they do not remember how they found out about his acquittal. At one time they could have said, but they no longer can.
- **Absent-mindedness:** People sometimes brush their teeth after already having brushed them or enter a room looking for something only to discover that they have forgotten what they were seeking.
- **Blocking**. People sometimes have something that they know they should remember, but they can't. It's as though the information is on the tip of their tongue, but they cannot retrieve it.
- **Misattribution**: People often cannot remember where they heard what they heard or read what they read. Sometimes people think they saw things they did not see or heard things they did not hear.
- **Suggestibility**: People are susceptible to suggestion, so if it is suggested to them that they saw something, they may think they

remember seeing it. For example, in one study, when asked whether they had seen a television film of a plane crashing into an apartment building, many people said they had seen it. There was no such film.

- **Bias**: People often are biased in their recall. For example, people who currently are experiencing chronic pain in their lives are more likely to remember pain in the past, whether or not they actually experienced it. People who are not experiencing such pain are less likely to recall pain in the past, again with little regard to their actual past experience.
- **Persistence**: People sometimes remember things as consequential that, in a broad context, are inconsequential. For example, someone with many successes but one notable failure may remember the single failure better than the many successes.

5. Deficient Memory

There are many syndromes associated with memory loss. The study of deficient memory provides us with many valuable insights into how memory works. In this section, we will have a look at two syndromes. The first and also most well known is amnesia. Afterwards, we will explore the symptoms and causes of Alzheimer's disease, which is another prominent disease that causes memory loss.

1) Amnesia : Amnesia is severe loss of explicit memory, scientists distinguished three types:

a) Retrograde amnesia, in which individuals lose their purposeful memory for events prior to whatever trauma induces memory loss

b) Anterograde amnesia, the inability to remember events that occur after a traumatic event

c) Infantile amnesia Another kind of "amnesia" that is the inability to recall events that happened when we were very young.

Amnesia and Neuropsychology Studies of amnesia victims have revealed much about the way in which memory depends on the effective functioning of particular structures of the brain. By looking for matches between particular lesions in the brain and particular deficits of function, researchers come to understand how normal memory functions. Thus, when studying cognitive processes in the brain, neuropsychologists frequently look for dissociations of function. In dissociations, normal individuals show the presence of a particular function (e.g., explicit memory). But people with specific lesions in the brain show the absence of that particular function. This absence occurs despite the presence of normal functions in other areas (e.g., implicit memory).

6.Alzheimer's Disease

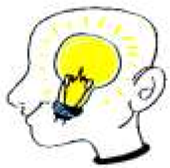
Alzheimer's disease is a disease of older adults that causes dementia as well as progressive memory loss (Kensinger & Corkin, 2003). Dementia is a loss of intellectual function that is severe enough to impair one's everyday life.

The memory loss in Alzheimer's disease can be seen in comparative brain scans of individuals with and without Alzheimer's disease. As the disease advances, there is diminishing cognitive activity in the areas of the brain associated with memory function.

Alzheimer's disease leads to an atrophy (decrease in size) of the brain; especially in the hippocampus and frontal and temporal brain regions (Jack et al., 2002). The brains of people with the disease show plaques and tangles that are not found in normal brains. Plaques are dense protein deposits found outside the nerve cells of the brain (Mirochnic et al., 2009). Tangles are pairs of filaments that become twisted around each other. Alzheimer's disease is diagnosed when memory is impaired and there is at least one other area of dysfunction in the domains of language, motor, attention, executive function, personality, or object recognition. The symptoms are of gradual onset, and the progression is continuous and irreversible.

Comprehension Check

- ♣ What is the difference between the sensory store and the short-term store?
- ♣ What are levels of processing?
- ♣ What are the components of the working-memory model?
- ♣ Why do we need both semantic and episodic memories?
- ♣ What is autobiographical memory?
- ♣ In what specific ways do memory distortions occur?
- ♣ Do you think eyewitness accounts should be allowed in court?
- ♣ What are repressed memories?



Chapter VII:

LANGUAGE

1. What Is Language?

There are almost 7,000 languages spoken in the world today (Lewis, 2009). It is to be expected that there are many more languages that linguists do not yet know about. What exactly constitutes a language, and are there some things that all languages have in common?

1.1.Properties of Language

Languages can be strikingly different, but they all have some commonalities. No matter what language you speak, language is (Brown, 1965; Clark & Clark, 1977):

a. Communicative: Language permits us to communicate with one or more people who share our language.

b. Arbitrarily symbolic: Language creates an arbitrary relationship between a symbol and what it represents: an idea, a thing, a process, a relationship, or a description.

c. Regularly structured: Language has a structure; only particularly patterned arrangements of symbols have meaning, and different arrangements yield different meanings.

d. Structured at multiple levels: The structure of language can be analyzed at more than one level (e.g., in sounds, meaning units, words, and phrases).

e. Generative, productive: Within the limits of a linguistic structure, language users can produce novel utterances. The possibilities for creating new utterances are virtually limitless.

f. Dynamic: Languages constantly evolve.

2. The Basic Components of Words

Language can be broken down into many smaller units. The smallest unit of speech sound is the phone, which is simply a single vocal sound. A phoneme is the smallest unit of speech sound that can be used to distinguish one utterance in a given language from another. At the next level of the hierarchy after the phoneme is the morpheme—the smallest unit of meaning within a particular language. The word recharge contains two morphemes, “re-” and “charge,” where “re” indicates a repeated action (Roca, 2003b).

English courses may have introduced you to two forms of morphemes—root words and affixes. Root words are the portions of words that contain the majority of meaning. These roots cannot be broken down into smaller meaningful units. They are the items that have entries in the dictionary (Motter et al., 2002). Examples of roots are the words “fix” and “active.” We add the second form of morphemes, affixes, to these root words. Affixes include prefixes, which precede the root word, and suffixes, which follow the root word.

Linguists analyze the structure of morphemes and of words in general in a way that goes beyond the analysis of roots and affixes. **Content morphemes** are the words that convey the bulk of the meaning of a language. **Function morphemes** add detail and nuance to the meaning of the content morphemes or help the content morphemes fit the grammatical context. Examples are the suffix -ist, the prefix de-, the conjunction and, or the article *the*.

The lexicon is the entire set of morphemes in a given language or in a given person’s linguistic repertoire. By combining morphemes, most adult English speakers have a vocabulary of hundreds of thousands of words. For example, by attaching just a few morphemes to the root content morpheme study, we have student, studious, studied, studying, and studies. Vocabulary is built up slowly.

3. The Basic Components of Sentences

A sentence comprises at least two parts. The first is a noun phrase, which contains at least one noun (often the subject of the sentence) and includes all the relevant descriptors of the noun (like "big" or "fast"). The second is a verb phrase (predicate), which contains at least one verb and whatever the verb acts on, if anything. Linguists consider the study of syntax to be fundamental to understanding the structure of language.

When we read and speak, it is important not only to comprehend words and sentences but also to figure out the meaning of whole conversations or larger written pieces. Semantics is the study of meaning in a language. A semanticist would be concerned with how words and sentences express meaning. Discourse encompasses language use at the level beyond the sentence, such as in conversation, paragraphs, stories, chapters, and entire works of literature.

4. Language Comprehension

Many processes are involved when we try to understand what somebody says. First of all, we need to perceive and recognize the words that are being said. Then we need to assign meaning to those words. In addition, we have to make sense of sentences we hear. These processes will be discussed in the next sections.

4.1.Understanding the Meaning of Words, Sentences, and Larger Text Units

4.1.1. Understanding Words

We are able to perceive speech with amazing rapidity. On the one hand, we can perceive as many as fifty phonemes per second in a language in which we are fluent (Foulke & Sticht, 1969). When confronted with non-speech sounds, on the other hand, we can perceive less than one phone per second (Warren et al., 1969). What makes Words perception even more complicated is that often we pronounce more than one sound at the same time. This is called **coarticulation**. One or more phonemes begin while other phonemes still are being produced.

This overlapping of speech sounds may seem to create additional problems for perceiving speech, but coarticulation is viewed as necessary for the effective transmission of speech information.

The process of trying to separate the continuous sound stream into distinct words is called **speech segmentation**. Thus, speech perception is viewed as different from other perceptual abilities because of both the linguistic nature of the information and the particular way in which information must be encoded for effective transmission.

5. The View of Speech Perception as Ordinary

One approach to speech perception suggests that when we perceive speech, we use the same processes as when we perceive other sounds. They suggest that there are different stages of neural processing: In one stage, speech sounds are analyzed into their components. In another stage, these components are analyzed for patterns and matched to a prototype or template. There are several theories about this issue among them:

- **The phonetic refinement theory.** It says that we start with an analysis of auditory sensations and shift to higher-level processing. We identify words on the basis of successively paring down the possibilities for matches between each of the phonemes and the words we already know from memory (Pisoni et al., 1985)
- **The TRACE model:** According to this model, speech perception begins with three levels of feature detection: the level of acoustic features, the level of phonemes, and the level of words. TRACE model works in a similar fashion of spreading activation. Phonemic information changes activation patterns in the network while information about words or their meaning can influence the analysis as well by prediction of which words are likely to appear next. Therefore, lower levels affect higher levels and vice versa (McClelland & Elman, 1986)

One attribute these theories have in common is that they all require decision making processes above and beyond feature detection or template matching.

- **The phonemic-restoration effect:** Because the speech we perceive may differ from the speech sounds that actually reach our ears. The reason is that cognitive and contextual factors influence our perception of the sensed signal. Thus, we integrate what we know with what we hear when we perceive speech (Kashino, 2006; Samuel, 1981).

6. The View of Speech Perception as Special

Some researchers suggest that speech-perception processes differ from the processes we use when we hear other sounds. We will explore this view further in the next sections by reviewing research on categorical perception and the motor theory of speech perception (Liberman et al., 1957)

6.1.Categorical Perception

One phenomenon in speech perception that led to the notion of specialization was the finding of categorical perception—discontinuous categories of speech sounds. That is, although the speech sounds we actually hear comprise a continuum of variation in sound waves, we experience speech sounds categorically. This phenomenon can be seen in the perception of the consonant– vowel combinations **ba, da**, and **ga**. A speech signal would look different for each of these syllables. Some patterns in the speech signal lead to the perception of ba.

Others lead to the perception of da. And still others lead to perception of ga. Additionally, the sound patterns for each syllable may differ as a result of other factors like pitch. The ba that you said yesterday differs from the ba you say today. But it is not perceived as different: It is perceived as belonging to the same category as the ba you said a few days ago or will say tomorrow. However, a non-speech sound such as a **tone** would be perceived as different.

Here, continuous differences in pitch (how high or low the tone is) are heard as continuous and distinct.

6.2.The Motor Theory of Speech Perception

According to the motor theory, we use the movements of the speaker's vocal tract to perceive what he says. Observing that a speaker rounds his lips or presses his lips together provides the listener with phonetic information. Thus, the listener uses specialized processes involved in producing speech to perceive speech. In fact, there is substantial overlap between the parts of the cortex that are involved in speech production and speech perception.

7. Understanding Meaning: Semantics

In semantics, **denotation** is the strict dictionary definition of a word. **Connotation** is a word's emotional overtones, presuppositions, and other non explicit meanings. Taken together, denotation and connotation form the meaning of a word. Because connotations may vary between people, there can be variation in the meaning formed.

How do we understand word meanings in the first place? Recall from previous chapters that we encode meanings into memory through concepts. These include ideas, to which we may attach various characteristics and with which we may connect various other ideas, such as through propositions (Rey, 2003). They also include images and perhaps motor patterns for implementing particular procedures. Here, we are concerned only with concepts, particularly in terms of words as arbitrary symbols for concepts.

8. Understanding Sentences: Syntax

Syntax is the systematic way in which words can be combined and sequenced to make meaningful phrases and sentences (Carroll, 1986). Whereas studies of speech perception chiefly investigate the phonetic structure of language, syntax focuses on the study of the grammar of phrases and sentences. In other words, it considers the regularity of structure.

In the following, the properties and impact of syntax will be explored in more detail. Phenomena such as syntactical priming and two main approaches to analyzing sentences: phrase-structure grammar and transformational grammar will also be highlighted.

8.1.Syntactical Priming

Just as we show semantic priming of word meanings in memory (that is, we react faster to words that are related in meaning to a prior presented word), we show syntactical priming of sentence structures. In other words, we spontaneously tend to use syntactical structures and read faster sentences that parallel the structures of sentences we have just heard. For example, a speaker will be more likely to use a passive construction (e.g.,"The student was praised by the professor") after hearing a passive construction. He or she will do so even when the topics of the sentences differ.

The preceding examples seem to indicate that we humans have some mental mechanism for classifying words according to syntactical categories. This classification mechanism is separate from the meanings for the words (Bock, 1990). When we compose sentences, we seem to analyze and divide them into functional components.

This process is called **parsing**. We assign appropriate syntactical categories (often called "parts of speech," e.g., noun, verb, article) to each component of the sentence. We then use the syntax rules for the language to construct grammatical sequences of the parsed components.

8.2.Phrase-structure grammar

Early in the 20th century, linguists who studied syntax largely focused on how sentences could be analyzed in terms of sequences of phrases, such as noun phrases and verb phrases, which were mentioned previously. They also focused on how phrases could be parsed into various syntactical categories, such as nouns, verbs, and adjectives. Such analyses look at **the phrase-structure grammar**—they analyze the structure of phrases as they are used. Let's have a closer look at the sentence:

"The girl looked at the boy with the telescope."

First of all, the sentence can be divided into the noun phrase (NP) "The girl" followed by a verb phrase (VP) "looked at the boy with the telescope." The noun phrase can be further divided into a determiner ("the") and a noun ("girl"). Likewise, the verb phrase can be further subdivided. However, the analysis of how to divide the verb phrase depends on what meaning the speaker had in mind. You may have noticed that the sentence can have two meanings:

(a) The girl looked with a telescope at the boy, **<u>or</u>**

(b) The girl looked at a boy who had a telescope.

In case (a), the verb phrase contains a verb (V; "looked"), and two prepositional phrases (PP; "at the boy" and "with the telescope"). In case (b), the verb phrase would again contain the verb "looked," but there is just one prepositional phrase ("looked at the boy with the telescope").

8.3.A New Approach to Syntax: Transformational Grammar

In transformational grammar, deep structure refers to an underlying syntactical structure that links various phrase structures through various transformation rules. In contrast, surface structure refers to any of the various phrase structures that may result from such transformations. Chomsky meant only to show that differing phrase structures may have a relationship that is not immediately apparent by using phrase-structure grammar alone. For example, the sentences,

"Susie greedily ate the crocodile," and "The crocodile was eaten greedily by Susie" have a relationship that cannot be seen just by looking at the phrase-structure grammar.

For detection of the underlying relationship between two phrase structures, transformation rules must be applied.

9. Understanding discourse

Discourse involves units of language larger than individual sentences—in conversations, lectures, stories, essays, and even textbooks (Di Eugenio, 2003). Just as grammatical sentences are structured according to systematic syntactical rules, passages of discourse are structured systematically.

Obviously, we can understand discourse only through analysis of words. But sometimes we understand words through discourse. For one example, sometimes in a conversation or watching a movie, we miss a word. The context of the discourse helps us figure out what the word was likely to be. As a second example, sometimes a word can have several meanings, such as “well.” We use discourse to help us figure out which meaning is intended.

As a third example, sometimes we realize, through discourse, that a word is intended to mean something different from its actual meaning, as in “Yeah, right!” Here, “right” is likely to be intended to mean “not really right at all.” So discourse helps us understand individual words, just as the individual words help us understand discourse.

10. Brain Structures Involved in Language

10.1.The Brain and Word Recognition

Studies have found that the middle part of the superior temporal sulcus (STS) responds more strongly to speech sounds than to non-speech sounds. The response takes place in both sides of the STS, although it is usually stronger in the left hemisphere (Binder, 2009).

10.2.The Brain and Semantic Processing

There are five brain regions that are involved in the storage and retrieval of meaning (Binder, 2009):

1) The ventral temporal lobes, including middle and inferior temporal, anterior fusiform, and anterior parahippocampal gyri;

2) The angular gyrus;

3) The anterior aspect (pars orbitalis) of the inferior frontal gyrus;

4) The dorsal prefrontal cortex; and

5) The posterior cingulate gyrus.

The activation of these areas takes place mostly in the left hemisphere, although there is some activation in the right hemisphere. It is suspected, however, that the right hemisphere does not play a significant role in word recognition

10.3.The Brain and Language Acquisition

In general, the left hemisphere seems to be better at processing well-practiced routines. The right hemisphere is better at dealing with novel stimuli. A possibly related finding is that individuals who have learned language later in life show more right-hemisphere involvement (Neville, 1995). Research findings suggest that one cannot precisely map linguistic or other kinds of functioning to hemispheres in a way that works for all people. Rather, the mappings differ somewhat from one person to another (Zurif, 1995).

11. Speech problems

11.1.Aphasia

Aphasia is an impairment of language functioning caused by damage to the brain. There are several types of aphasias.

11.1.1. Wernicke's Aphasia

Wernicke's aphasia is caused by damage to Wernicke's area of the brain. It is characterized by notable impairment in the understanding of spoken words and sentences. It also typically involves the production of sentences that have the basic structure of the language spoken but that make no sense. They are sentences that are empty of meaning. There are two cases: In the first case, the words make sense, but not in the context they are presented. In the second case, the words themselves are neologisms, or newly created words. Treatment for patients with this type of aphasia frequently involves supporting and encouraging non-language communication.

11.1.2. Broca's Aphasia

Broca's aphasia is caused by damage to Broca's area of the brain. It is characterized by the production of agrammatical speech at the same time that verbal comprehension ability is largely preserved. It thus differs from Wernicke's aphasia in two key respects. First is that speech is agrammatical rather than grammatical (as in Wernicke's). Second is that verbal comprehension is largely preserved.

11.1.3. Global Aphasia

Global aphasia is the combination of highly impaired comprehension and production of speech. It is caused by lesions to both Broca's and Wernicke's areas.

11.1.4. Anomic Aphasia

Anomic aphasia involves difficulties in naming objects or in retrieving words. The patient may look at an object and simply be unable to retrieve the word that corresponds to the object.

11.2.Autism

Autism is a developmental disorder characterized by abnormalities in social behavior, language, and cognition. It is biological in its origins, and researchers have already identified some of the genes associated with it (Wall et al., 2009). Children with autism show abnormalities in many areas of the brain. It is five times more common in males than in females.

Children with autism usually are identified by around 14 months of age, when they fail to show expected normal patterns of interactions with others. Children with autism display repetitive movements and stereotyped patterns of interests and activities. Often they repeat the same motion, over and over again, with no obvious purpose to the movement. When they interact with someone, they are more likely to view their lips than their eyes.

About half of children with autism fail to develop functional speech. People with autism also may have problems with the semantic encoding of language.

Comprehension Check

- ♣ What is coarticulation, and why is it important?
- ♣ What does the view of speech perception as ordinary suggest?
- ♣ What is categorical perception?
- ♣ What is syntactical priming?
- ♣ What is the difference between phrase-structure grammar and transformational grammar?
- ♣ What is the difference between Wernicke's aphasia and Broca's aphasia?

Chapter VIII: Intelligence

1. Definition

Intelligence is a concept that can be viewed as tying together all of cognitive psychology. Just what is intelligence, beyond the basic definition? In a recent article, researchers identified approximately 70 different definitions of intelligence. It involves:

1. The capacity to learn from experience, and

2. The ability to adapt to the surrounding environment

2. Three Cognitive Models of Intelligence

There have been many models of intelligence. Three models are particularly useful when linking human intelligence to cognition: ***the three-stratum model, the theory of multiple intelligences, and the triarchic theory of intelligence.***

2.1.Carroll Three-Stratum Model of Intelligence

According to the three-stratum model of intelligence, intelligence comprises a hierarchy of cognitive abilities comprising three strata (Carroll, 1993):

• **Stratum I** includes many narrow, specific abilities (e.g., spelling ability, speed of reasoning).

• **Stratum II** includes various broad abilities (e.g., fluid intelligence (speed and accuracy, crystallized intelligence (abundance of knowledge), short-term memory, long-term storage and retrieval, information processing speed).

• **Stratum III** is just a single general intelligence (sometimes called g).

Of these strata, the most interesting is the middle stratum, which is neither too narrow nor too all-encompassing.

In the middle stratum are fluid ability and crystallized ability. Fluid ability is speed and accuracy of abstract reasoning, especially for novel problems. Crystallized ability is accumulated knowledge and vocabulary (Cattell, 1971). In addition to fluid intelligence and crystallized intelligence, Carroll includes several other abilities in the middle stratum. They are learning and memory processes, visual perception, auditory perception, facile production of ideas (similar to verbal fluency), and speed (which includes both sheer speed of response and speed of accurate responding). Carroll's model is probably the most widely accepted of the measurement-based models of intelligence.

2.2.Gardner: Theory of Multiple Intelligences

Howard Gardner (2006) has proposed a theory of multiple intelligences, in which intelligence comprises multiple independent constructs, not just a single, unitary construct. However, instead of speaking of multiple abilities that together constitute intelligence (e.g., Thurstone, 1938), this theory distinguishes eight distinct intelligences that are relatively independent of each other (Table 1.1).

Each is a separate system of functioning, although these systems can interact to produce what we see as intelligent performance. Looking at Gardner's list of intelligences.

On which of Howard Gardner's eight intelligences do you show the greatest ability in what contexts can you us your intelligences most effectively (after Gardner, 1999)

Type of intelligence	**Tasks reflecting this type of intelligence**
Linguistic intelligence	Used in reading a book, writing a paper, a novel, or a poem, and understanding spoken words.
Logical-mathematical intelligence	Used in solving math problems in balancing a check-book, in salving a mathematical proof, and in logical reasoning.
Spatial intelligence	Used in gelling from place to another, in reading a map, and in pocking suitcases in the trunk of a car so that they all fit into a compact space.
Musical intelligence	Used in singing a song, composing a sonata, playing a trumpet, or even appreciating the structure of a piece of music.
Bodily kinesthetic intelligence	Used in relating to other people such as when we try to understand another person's behavior, motives, or emotions.
Intrapersonal intelligence	Used in relating to other people, such as when we try to understand another person's behavior, motives, or emotions.
Intrapersonal intelligence	Used in understanding ourselves-the basis for under- standing who we are, what makes us tick, and how we can change ourselves, given our existing. Constraints on our abilities and our interests
Naturalist intelligence	Used in understanding patterns in nature.

2.3.Sternberg: The Triarchic Theory of Intelligence

Whereas Gardner emphasizes the separateness of the various aspects of intelligence, Robert Sternberg tends to emphasize the extent to which they work together in his triarchic theory of human intelligence (Sternberg, 1999).

According to the triarchic theory of human intelligence, intelligence comprises three aspects: creative, analytical, and practical.

- **Creative abilities** are used to generate novel ideas.
- **Analytical abilities** ascertain whether your ideas (and those of others) are good ones.
- **Practical abilities** are used to implement the ideas and persuade others of their value.

According to the theory, cognition is at the center of intelligence. Information processing in cognition can be viewed in terms of three different kinds of components.

♣ **First** are metacomponents—higher-order executive processes (i.e., metacognition) used to plan, monitor, and evaluate problem solving.

♣ **Second** are performance components—lower-order processes used for implementing the commands of the metacomponents. And

♣ **Third** are knowledge-acquisition components—the processes used for learning how to solve the problems in the first place. The components are highly interdependent.

Suppose that you were asked to write a term paper. You would use metacomponents for higher-order decisions. Thus, you would use them to decide on a topic, plan the paper, monitor the writing, and evaluate how well your finished product succeeds in accomplishing your goals for it. You would use knowledge-acquisition components for research to learn about the topic. You would use performance components for the actual writing.

3. Intelligence and Neuroscience

The human brain is clearly the organ that serves as a biological basis for human intelligence.

3.1.Intelligence and Brain Size

The evidence suggests that, for humans, there is a modest but significant statistical relationship between brain size and intelligence (Gignac, Vernon, & Wickett, 2003). The amount of gray matter in the brain is strongly correlated with IQ in many areas of the frontal and temporal lobes (Haier, Jung, Yeo, Head, & Alkire, 2004). However, the brain areas that are correlated with IQ appear to differ in men versus women. Frontal areas are of relatively more importance in women, whereas posterior areas are of relatively more importance in men, even if both genders are matched for intelligence (Haier, Jung, Yeo, Head, & Alkire, 2005).

3.2.Intelligence and Neurons

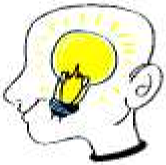
The development of electrical recording and imaging techniques offers some appealing possibilities. For example, complex patterns of electrical activity in the brain, which are prompted by specific stimuli, appear to correlate with scores on IQ tests (Barrett & Eysenck, 1992). Surprisingly, neural conduction velocity appears to be a more powerful predictor of IQ scores for men than for women. So gender differences may also account for some of the differences in the data (Wickett & Vernon, 1994).

3.3.The P-FIT Theory of Intelligence

The discovered importance of the frontal and parietal regions in intelligence tasks has led to the development of an integrated theory of intelligence that highlights the importance of these areas. This theory, called **the parietal-frontal integration theory (P-FIT)**, stresses the importance of interconnected brain regions in determining differences in intelligence. The regions this theory focuses on are the prefrontal cortex, the inferior and superior parietal lobe, the anterior cingulated cortex, and portions of the temporal and occipital lobes (Colom et al., 2009). **P-FIT theory** describes patterns of brain activity in people with different levels of intelligence; it cannot, however, explain what makes a person intelligent or what intelligence is.

Comprehesion Check

- ♣ Explain why the concept of Intelligence is perceived differently ?
- ♣ What are the cognitive models of intelligence ?
- ♣ Explain how do brain areas that are correlated with IQ differ from men to women ?



Chapter IX: Problem Solving and Creativity

1. The Problem-Solving Cycle

The problem-solving cycle includes: problem identification, problem definition, strategy formulation, organization of information, allocation of resources, monitoring, and evaluation (Bransford & Stein, 1993), as illustrated in figure (12).

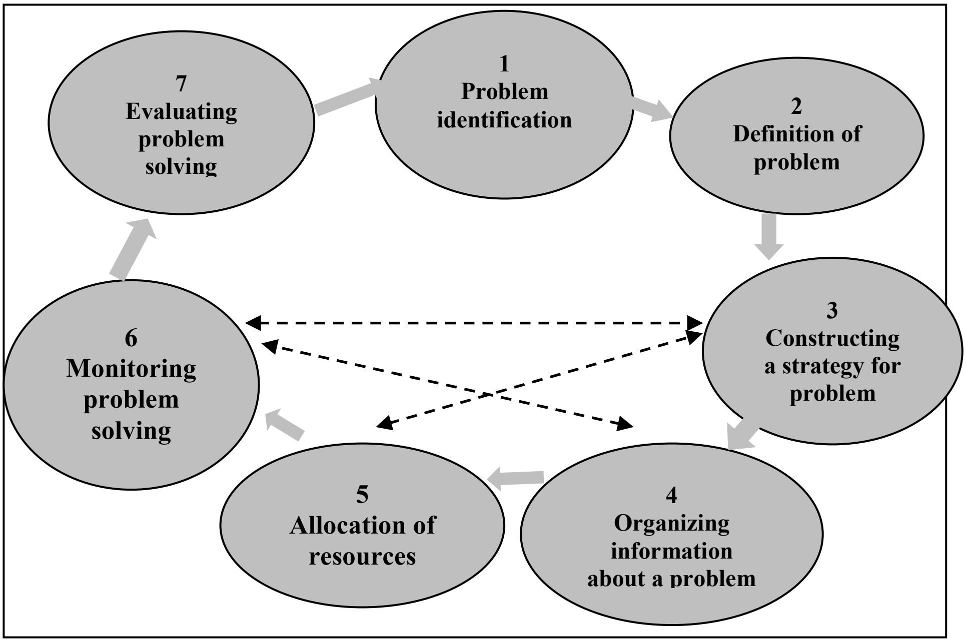


Figure (11): The Problem-Solving Cycle (Bransford & Stein, 1993)

Following is a description of each part of the problem-solving cycle.

1. Problem identification: Do we actually have a problem?

2. Problem definition and representation: What exactly is our problem?

3. Strategy formulation: How can we solve the problem? The strategy may involve.

analysis—breaking down the whole of a complex problem into manageable elements.

Instead, or perhaps in addition, it may involve the complementary process of **synthesis**—putting together various elements to arrange them into something useful.

Another pair of complementary strategies involves **divergent and convergent thinking.** In divergent thinking, you try to generate a diverse assortment of possible alternative solutions to a problem. Once you have considered a variety of possibilities, however, you must engage in convergent thinking to narrow down the multiple possibilities to converge on a single best answer.

4. Organization of information: How do the various pieces of information in the problem fit together?

5. Resource allocation: How much time, effort, money, etc., should I put into this problem?

6. Monitoring: Am I on track as I proceed to solve the problem?

7. Evaluation: Did I solve the problem correctly?

In considering the steps, flexibility in following the various steps of the cycle is important. Successful problem solving may involve occasionally tolerating some ambiguity regarding how best to proceed. Rarely can we solve problems by following any one optimal sequence of problem-solving steps. We may go back and forth through the steps. We can change their order, or even skip or add steps when it seems appropriate.

2. Types of Problems

Problems can be categorized according to whether they have clear paths to a solution

2.1Well-structured problems

They have clear paths to solutions. These problems also are termed well-defined problems. An example would be, "How do you find the area of a parallelogram?"

2.2.Ill-structured problems

They lack clear paths to solutions (Shin et al., 2003). These problems are also termed ill-defined problems. For example, "How do you tie together two suspended strings, when neither string is long enough to allow you to reach the other string while holding either of the strings?"

3. Obstacles and Aids to Problem Solving

Several factors can hinder or enhance problem solving. Among them are mental sets as well as positive and negative transfer. Incubation plays a role in problem solving as well.

3.1.Mental Sets, Entrenchment, and Fixation

One factor that can hinder problem solving is **mental set**—a frame of mind involving an existing model for representing a problem, a problem context, or a procedure for problem solving. Another term for mental set is **entrenchment.** When problem solvers have an entrenched mental set, they **fixate** on a strategy that normally works well in solving many problems but that does not work well in solving this particular problem. For example, in the two-string problem, you may fixate on strategies that involve moving yourself toward the string, rather than moving the string toward you.

3.2.Negative and Positive Transfer

Often, people have particular mental sets that prompt them to fixate on one aspect of a problem or one strategy for problem solving to the exclusion of other possible relevant ones. They are carrying knowledge and strategies for solving one kind of problem to a different kind of problem. **Transfer** is any carryover of knowledge or skills from one problem situation to another (Detterman & Sternberg, 1993).

3.2.1.Negative transfer

It occurs when solving an earlier problem makes it harder to solve a later one. Sometimes an early problem gets an individual on a wrong track. For example, police may have difficulty solving a political crime because such a crime differs so much from the kinds of crime that they typically deal with. Or when presented with a new tool, a person may operate it in a way similar to the way in which he or she operated a tool with which he or she was already familiar (Besnard & Cacitti, 2005).

3.2.2.Positive transfer

It occurs when the solution of an earlier problem makes it easier to solve a new problem. That is, sometimes the transfer of a mental set can be an aid to problem solving. For instance, one may transfer early math skills, such as addition, to advanced math problems of the kinds found in algebra or physics (Bassok & Holyoak, 1989)

3.3.Incubation

Putting the problem aside for a while without consciously thinking about it is called incubation. This offers one way in which to minimize negative transfer. It involves taking a pause from the stages of problem solving.

For example, suppose you find that you are unable to solve a problem. None of the strategies you can think of seem to work. During incubation, you must not consciously think about the problem. You do, however, allow for the possibility that the problem will be processed subconsciously. Some investigators of problem solving have even asserted that incubation is an essential stage of the problem-solving process (Cattell, 1971), because people continue to process, below consciousness, information about a problem on which they are incubating at the same time that they are attending to other matters.

4. Neuroscience and Planning during Problem Solving

The frontal lobes and in particular the prefrontal cortex are essential for planning for complex problem-solving tasks. A number of studies have highlighted activation in this region of the brain during problem solving (Unterrainer & Owen, 2006). Additionally, both the left and right prefrontal areas are active during the planning stage of complex problem solving (Newman et al., 2003). Further evidence for the importance of the prefrontal regions in problem solving can be seen in cases of traumatic brain injury. Both problem solving and planning ability decline following traumatic brain injury (Catroppa & Anderson, 2006).

5. Creativity

Creativity is defined as the process of producing something that is both original and worthwhile. It might be a theory, a dance, a chemical, a process or procedure, a story, a symphony, or almost anything else. Creative individuals produce inventions, insightful discoveries, artistic works, revolutionary paradigms, or other products that are both original and worthwhile. Conventional wisdom suggests that highly creative individuals also have creative lifestyles. These lifestyles are characterized by flexibility, non-stereotyped behaviors, and non-conforming attitudes.

5.1.The characteristics of creative people

Creativity involves producing something that is both original and worthwhile. Several factors characterize highly creative individuals. One is extremely high motivation to be creative in a particular field of endeavor (e.g., for the sheer enjoyment of the creative process).

A second factor is both non-conformity in violating any conventions that might inhibit the creative work and dedication in maintaining standards of excellence and self-discipline related to the creative work. A third factor in creativity is deep belief in the value of the creative work, as well as willingness to criticize and improve the work. A fourth is careful choice of the problems or subjects on which to focus creative attention. A fifth characteristic of creativity is thought processes characterized by both insight and divergent thinking. A sixth factor is risk taking.

The final two factors in creativity are extensive knowledge of the relevant domain and profound commitment to the creative endeavor. In addition, the historical context and the domain and field of endeavor influence the expression of creativity.

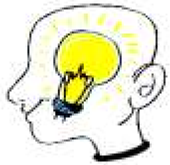
5.2.Neuroscience and Creativity

The examination of creative thought and production has led researchers to identify brain regions that are active during creativity. The prefrontal regions are especially active during the creative process, regardless of whether the creative thought is effortful or spontaneous (Dietrich, 2004).

Previous research has indicated that Brodmann's areas are involved in verbal working memory, task switching, and imagination (Blackwood et al., 2000).

Comprehension Check

- Why is the process of solving problems described as a cycle?
- What are the different steps of the problem-solving cycle?
- How can mental sets impair our problem-solving ability?
- What is negative transfer?
- Are analogies always useful for problem solving?
- What is the role of incubation in problem solving?



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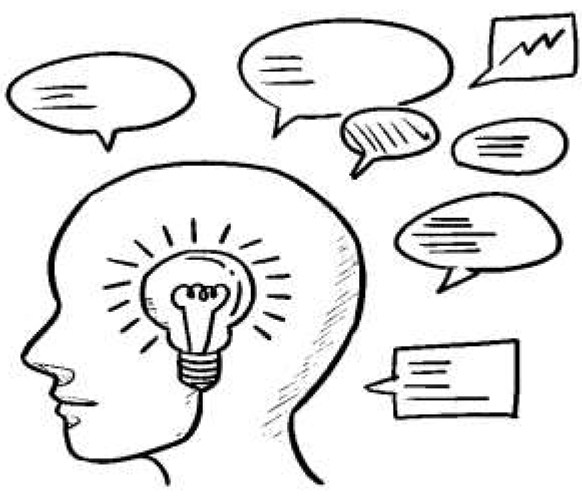

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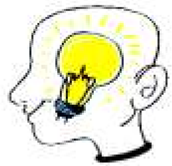
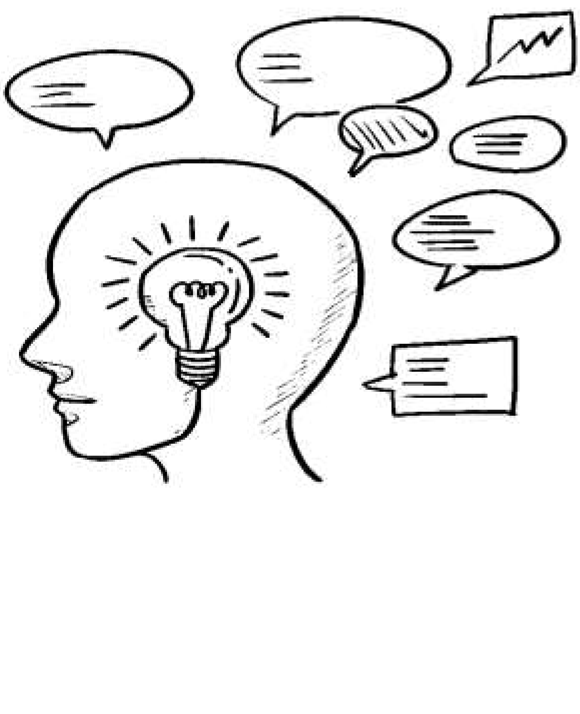


Glossary



Glossary

Accessibility the degree to which we can gain access to the available information

ACT Adaptive Control of Thought. In his ACT model, John Anderson synthesized some of the features of serial information-processing models and some of the features of semantic-network models. In ACT, procedural knowledge is represented in the form of production systems. Declarative knowledge is represented in the form of propositional networks

ACT-R a model of information processing that integrates a network representation for declarative knowledge and a production-system representation for procedural knowledge

agnosia a severe deficit in the ability to perceive sensory information

algorithms sequences of operations that may be repeated over and over again and that, in theory, guarantee the solution to a problem

Alzheimer's disease a disease of older adults that causes dementia as well as progressive memory loss

amacrine cells along with horizontal cells, they make single lateral connections among adjacent areas of the retina in the middle layer of cells

amnesia severe loss of explicit memory

amygdala plays an important role in emotion, especially in anger and aggression

analog codes a form of knowledge representation that preserves the main perceptual features of whatever is being represented for the physical stimuli we observe in our environment

analysis breaking down the whole of a complex problem into manageable elements

anterograde amnesia the inability to remember events that occur after a traumatic event

Glossary

aphasia an impairment of language functioning caused by damage to the brain

arousal a degree of physiological excitation, responsivity, and readiness for action, relative to a baseline

artifact categories groupings that are designed or invented by humans to serve particular purposes or functions

artificial intelligence (AI) the attempt by humans to construct systems that show intelligence and, particularly, the intelligent processing of information; intelligence in symbol-processing systems such as computers

associationism examines how events or ideas can become associated with one another in the mind to result in a form of learning

attention the active cognitive processing of a limited amount of information from the vast amount of information available through the senses, in memory, and through cognitive processes; focus on a small subset of available stimuli

autobiographical memory refers to memory of an individual's history

automatic processes involve no conscious control

automatization the process by which a procedure changes from being highly conscious to being relatively automatic; also termed proceduralization

availability the presence of information stored in long-term memory

availability heuristic cognitive shortcut that occurs when we make judgments on the basis of how easily we can call to mind what we perceive as relevant instances of a phenomenon

axon the part of the neuron through which intraneuronal conduction occurs (via the action potential) and at the terminus of which is located the terminal buttons that release neurotransmitters

base rate refers to the prevalence of an event or characteristic within its population of events or characteristics

Glossary

basic level degree of specificity of a concept that seems to be a level within a hierarchy that is preferred to other levels; sometimes termed natural level

behaviorism a theoretical outlook that psychology should focus only on the relation between observable behavior, on the one hand, and environmental events or stimuli, on the other

bilinguals people who can speak two languages

binaural presentation presenting the same two messages, or sometimes just one message, to both ears simultaneously

binocular depth cues based on the receipt of sensory information in three dimensions from both eyes

bipolar cells make dual connections forward and outward to the ganglion cells, as well as backward and inward to the third layer of retinal cells

blindsight traces of visual perceptual ability in blind areas

bottleneck theories theories proposing a bottleneck that

slows down information passing through

bottom-up theories data-driven (i.e., stimulus-driven) theories

bounded rationality belief that we are rational, but within limits

brain the organ in our bodies that most directly controls our thoughts, emotions, and motivations

declarative knowledge knowledge of facts that can be stated

deductive reasoning the process of reasoning from one or more general statements regarding what is known to reach a logically certain conclusion

deductive validity logical soundness

deep structure refers to an underlying syntactic structure that

links various phrase structures through the application of various transformation rules

defining feature a necessary attribute

dendrites the branch-like structures of each neuron that extend into synapses with other neurons and that receive neurochemical messages sent into synapses by other neurons

denotation the strict dictionary definition of a word

dependent variable a response that is measured and is presumed to be the effect of one or more independent variables

depth the distance from a surface, usually using your own body as a reference surface when speaking in terms of depth perception

dialect a regional variety of a language distinguished by features such as vocabulary, syntax, and pronunciation

dichotic presentation presenting a different message to each ear

direct perception theory belief that the array of information in our sensory receptors, including the sensory context, is all we need to perceive anything

discourse encompasses language use at the level beyond the sentence, such as in conversation, paragraphs, stories, chapters, and entire works of literature

dishabituation change in a familiar stimulus that prompts us to start noticing the stimulus again

distracters nontarget stimuli that divert our attention away from the target stimulus

distributed practice learning in which various sessions are spaced over time

divergent thinking when one tries to generate a diverse assortment of possible alternative solutions to a problem

divided attention the prudent allocation of available attentional resources to coordinate the performance of more than one task at a time

dual-code theory belief suggesting that knowledge is represented both in images and in symbols

dual-system hypothesis suggests that two languages are represented somehow in separate systems of the mind

dyslexia difficulty in deciphering, reading, and comprehending text

Glossary

ecological validity the degree to which particular findings in one environmental context may be considered relevant outside that context

electroencephalograms (EEGs) recordings of the electrical frequencies and intensities of the living brain, typically recorded over relatively long periods

elimination by aspects occurs when we eliminate alternatives by focusing on aspects of each alternative, one at a time

emotional intelligence the ability to perceive and express emotion, assimilate emotion in thought, understand and reason with emotion, and regulate emotion in the self and others

empiricist one who believes that we acquire knowledge via empirical evidence

encoding refers to how you transform a physical, sensory input into a kind of representation that can be placed into memory

encoding specificity what is recalled depends on what is encoded

episodic buffer a limited-capacity system that is capable of binding information from the subsidiary systems and from long-term memory into a unitary episodic representation

episodic memory stores personally experienced events or episodes

event-related potential an electrophysiological response to a stimulus, whether internal or external

executive attention a subfunction of attention that includes processes for monitoring and resolving conflicts that arise among internal processes

exemplars typical representatives of a category

expertise superior skills or achievement reflecting a welldeveloped and well-organized knowledge base

expert systems computer programs that can perform the way an expert does in a fairly specific domain

explicit memory when participants engage in conscious recollection

Glossary

factor analysis a statistical method for separating a construct into a number of hypothetical factors or traits that the researchers believe form the basis of individual differences in test performance

fallacy erroneous reasoning

feature-integration theory explains the relative ease of conducting feature searches and the relative difficulty of conducting conjunction searches

feature-matching theories suggest that we attempt to match features of a pattern to features stored in memory

feature search simply scanning the environment for a particular feature or features

figure-ground what stands out from versus what recedes into the background

filter theories theories proposing a filter that blocks some of the information going through and thereby selects only a part of the total of information to pass through to the next stage

flashbulb memory a memory of an event so powerful that the person remembers the event as vividly as if it were indelibly preserved on film

flow chart a model path for reaching a goal or solving a problem

fovea a part of the eye located in the center of the retina that is largely responsible for the sharp central vision people

language the use of an organized means of combining words in order to communicate

law of Prägnanz tendency to perceive any given visual array in a way that most simply organizes the disparate elements into a stable and coherent form

levels-of-processing framework postulates that memory does not comprise three or even any specific number of separate stores but rather varies along a continuous dimension in terms of depth of encoding

lexical access the identification of a word that allows us to gain access to the meaning of the word from memory

lexical processes used to identify letters and words

Glossary

lexicon the entire set of morphemes in a given language or in a given person's linguistic repertoire

limbic system important to emotion, motivation, memory, and learning

linguistic relativity the assertion that speakers of different languages have differing cognitive systems and that these different cognitive systems influence the ways in which people speaking the various languages think about the world

linguistic universals characteristic patterns across all languages of various cultures

lobes divide the cerebral hemispheres and cortex into four parts

localization of function refers to the specific areas of the brain that control specific skills or behaviors

long-term store very large capacity, capable of storing information for very long periods, perhaps even indefinitely

magnetic resonance imaging (MRI) scan a technique for revealing high-resolution images of the structure of the living brain by computing and analyzing magnetic changes in the energy of the orbits of nuclear particles in the molecules of the body

magnetoencephalography (MEG) an imaging technique that measures the magnetic fields generated by electrical activity in the brain by highly sensitive measuring devices

massed practice learning in which sessions are crammed together in a very short space of time

medulla oblongata brain structure that controls heart activity and largely controls breathing, swallowing, and digestion

memory the means by which we retain and draw on our past experiences to use this information in the present

Glossary

mental models knowledge structures that individuals construct to understand and explain their experiences; an internal representation of information that corresponds analogously with whatever is being represented

mental rotation involves rotationally transforming an object's visual mental image

mental set a frame of mind involving an existing model for representing a problem, a problem context, or a procedure for problem solving

metacognition our understanding and control of our cognition; our ability to think about and control our own

processes of thought and ways of enhancing our thinking

metamemory strategies involve reflecting on our own memory processes with a view to improving our memory

metaphor two nouns juxtaposed in a way that positively asserts their similarities, while not disconfirming their dissimilarities

mnemonic devices specific techniques to help you memorize lists of words

mnemonist someone who demonstrates extraordinarily keen memory ability, usually based on the use of special techniques for memory enhancement

modular divided into discrete modules that operate more or less independently of each other

monocular depth cues can be represented in just two dimensions and observed with just one eye

monolinguals people who can speak only one language

morpheme the smallest unit that denotes meaning within a particular language

multimode theory proposes that attention is flexible; selection of one message over another message can be made at any of various different points in the course of information

processing

Glossary

myelin a fatty substance coating the axons of some neurons that facilitates the speed and accuracy of neuronal communication

natural categories groupings that occur naturally in the world

negative transfer occurs when solving an earlier problem makes it harder to solve a later one

nervous system the organized network of cells (neurons) through which an individual receives information from the environment, processes that information, and then interacts with the environment

networks a web of relationships (e.g., category membership, attribution) between nodes

neurons individual nerve cells

neurotransmitters chemical messengers used for interneuronal communication

nodes the elements of a network

nodes of Ranvier gaps in the myelin coating of myelinated axons

nominal kind the arbitrary assignment of a label to an entity that meets a certain set of prespecified conditions

noun phrase syntactic structure that contains at least one noun (often, the subject of the sentence) and includes all the relevant descriptors of the noun

object-centered representation the individual stores a representation of the object, independent of its appearance to the viewer

occipital lobe associated with visual processing, the primary motor cortex, which specializes in the planning, control, and execution of movement, particularly of movement involving any kind of delayed response

recall to produce a fact, a word, or other item from memory

recency effect refers to superior recall of words at and near the end of a list

recognition to select or otherwise identify an item as being one that you learned previously

Glossary

recognition-by-components (RBC) theory the belief that we quickly recognize objects by observing the edges of objects and then decomposing the objects into geons

reconstructive involving the use of various strategies (e.g., searching for cues, drawing inferences) for retrieving the original memory traces of our experiences and then

rebuilding the original experiences as a basis for retrieval

referent the thing or concept in the real world that a word refers to

rehearsal the repeated recitation of an item

representativeness occurs when we judge the probability of an uncertain event according to (1) its obvious similarity to or representation of the population from which it is derived and (2) the degree to which it reflects the salient features of the process by which it is generated

(such as randomness)

reticular activating system (RAS) a network of neurons essential to the regulation of consciousness (sleep, wakefulness, arousal, and even attention to some extent and to such vital functions as heartbeat and breathing); also called reticular formation

retina a network of neurons extending over most of the back (posterior) surface of the interior of the eye. The retina is where electromagnetic light energy is transduced—

that is, converted—into neural electrochemical impulses

retrieval (memory) refers to how you gain access to information stored in memory

retroactive interference caused by activity occurring after we learn something but before we are asked to recall that thing; also called retroactive inhibition

retrograde amnesia occurs when individuals lose their purposeful

memory for events prior to whatever trauma induces memory loss

rods light-sensitive photoreceptors in the retina of the eye that provide peripheral vision and the ability to see objects at night or in dim light; rods are not color sensitive

satisficing occurs when we consider options one by one, and then we select an option as soon as we find one that is satisfactory or just good enough to meet our minimum level of acceptability

schemas mental frameworks for representing knowledge that encompass an array of interrelated concepts in a meaningful organization

script a structure that describes appropriate sequences of events in a particular context

search refers to a scan of the environment for particular features— actively looking for something when you are not sure where it will appear

selective attention choosing to attend to some stimuli and to ignore others

selective-combination insight involves taking selectively encoded and compared snippets of relevant information and combining that information in a novel, productive way

selective-comparison insight involves novel perceptions of how new information relates to old information

selective-encoding insight involves distinguishing relevant from irrelevant information

semantic memory stores general world knowledge

semantic network a web of interconnected elements of meaning

semantics the study of meaning in a language

sensory adaptation a lessening of attention to a stimulus that is not subject to conscious control

sensory store capable of storing relatively limited amounts of information for very brief periods

septum is involved in anger and fear

Glossary

serial-position curve represents the probability of recall of a given word, given its serial position (order of presentation) in a list

serial processing means by which information is handled through a linear sequence of operations, one operation at a time

short-term store capable of storing information for somewhat longer periods but also of relatively limited capacity

signal a target stimulus

signal detection the detection of the appearance of a particular stimulus

signal-detection theory (SDT) a theory of how we detect stimuli that involves four possible outcomes of the presence or absence of a stimulus and our detection or nondetection of a stimulus

simile introduces the word like or as into a comparison between items

single-system hypothesis suggests that two languages are represented in just one system

slips of the tongue inadvertent linguistic errors in what we say

soma the cell body of a neuron that is the part of the neuron essential to the life and reproduction of the cell

spacing effect refers to the fact that long-term recall is best when the material is learned over a longer period of time

spatial cognition refers to the acquisition, organization, and use of knowledge about objects and actions in two- and three-dimensional space

speech acts addresses the question of what you can accomplish with speech

split-brain patients people who have undergone operations
severing the corpus callosum

spreading activation excitation that fans out along a set of nodes within a given network

statistical significance indicates the likelihood that a given
set of results would be obtained if only chance factors were in operation

Glossary

stereotypes beliefs that members of a social group tend more or less uniformly to have particular types of characteristics

storage (memory) refers to how you retain encoded information in memory

Stroop effect demonstrates the psychological difficulty in selectively attending to the color of the ink and trying to ignore the word that is printed with the ink of that color

structuralism seeks to understand the structure (configuration of elements) of the mind and its perceptions by analyzing those perceptions into their constituent components

structure-of-intellect (SOI) Guilford's model for a threedimensional structure of intelligence, embracing various contents, operations, and products of intelligence

subjective probability a calculation based on the individual's estimates of likelihood, rather than on objective statistical computations

subjective utility a calculation based on the individual's judged weightings of utility (value), rather than on objective criteria

surface structure a level of syntactic analysis that involves the specific syntactical sequence of words in a sentence and any of the various phrase structures that may result

syllogisms deductive arguments that involve drawing conclusions from two premises

symbolic representation meaning that the relationship between the word and what it represents is simply arbitrary

synapse a small gap between neurons that serves as a point of contact between the terminal buttons of one or more neurons and the dendrites of one or more other neurons

syntax refers to the way in which users of a particular language put words together to form sentences

Glossary

synthesis putting together various elements to arrange them into something useful

templates highly detailed models for patterns we potentially might recognize

temporal lobe associated with auditory processing

terminal buttons knobs at the end of each branch of an axon; each button may release a chemical neurotransmitter as a result of an action potential

thalamus relays incoming sensory information through groups of neurons that project to the appropriate region in the cortex

thematic roles ways in which items can be used in the context of communication

theory an organized body of general explanatory principles regarding a phenomenon

theory-based view of meaning holds that people understand and categorize concepts in terms of implicit theories, or general ideas they have regarding those concepts

theory of multiple intelligences belief that intelligence comprises multiple independent constructs, not just a single, unitary construct

tip-of-the-tongue phenomenon experience of trying to remember something that is known to be stored in memory but that cannot readily be retrieved

top-down theories driven by high-level cognitive processes, existing knowledge, and prior expectations

transcranial magnetic stimulation (TMS) technique that temporarily disrupts the normal activity of the brain in a limited area. This technique requires placing a coil on a person's head and then allowing an electrical current to pass though it. The current generates a magnetic field. This field disrupts the small area (usually no more than a cubic centimeter) beneath it.

The researcher can then look at cognitive functioning when the particular area is disrupted

transfer any carryover of knowledge or skills from one problem situation to another

transformational grammar involves the study of transformational rules that guide the ways in which underlying propositions can be rearranged to form various phrase structures

transparency occurs when people see analogies where they do not exist because of similarity of content

triarchic theory of human intelligence belief that intelligence comprises three aspects, dealing with the relation of intelligence (1) to the internal world of the person, (2) to experience, and (3) to the external world

verbal comprehension the receptive ability to comprehend written and spoken linguistic input, such as words, sentences, and paragraphs

verbal fluency the expressive ability to produce linguistic output

verb phrase syntactic structure that contains at least one verb and whatever the verb acts on, if anything

viewer-centered representation an individual stores the way the object looks to him or her

vigilance refers to a person's ability to attend to a field of stimulation over a prolonged period, during which the person seeks to detect the appearance of a particular target stimulus of interest

visuospatial sketchpad briefly holds some visual images

well-structured problems problems that have well-defined paths to solution

word-superiority effect letters are read more easily when they are embedded in words than when they are presented either in isolation or with letters that do not form words

Glossary

working memory holds only the most recently activated portionof long-term memory, and it moves these activated elements into and out of brief, temporary memory storage.

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