1

PERCEPTION: RECOGNIZING PATTERNS AND OBJECTS - I

Unit Structure

1.0 OBJECTIVES

After studying the Unit, the learner will be able to understand:

- What is the nature of perception?
- What are the various theoretical approaches to understand the process of perception?
- What are the different perceptual organizations within the human system?

1.1 INTRODUCTION

The organization of sensory experience of the world is referred to as perception. It entails recognizing environmental stimuli as well as acting in response to these stimuli. We learn about the environment's essential qualities and elements through the perception process. It is via perception that we are able to not only make sense of the world around us, but also to take action within it.

This unit will examine visual, auditory, and somatic perception as sources of perceptual information. This perceptual information is vital for navigating our physical and social environments. It would be easy to learn about perception if our perceptual representations had all the important information about the physical world in them.

1.1.1 BASIC NATURE OF PERCEPTION

The perceptual process consists of a series of steps that begin with environmental stimuli and end with our interpretation of those stimuli. Perception is the process of making sense of sensory data. In other words, sensation is the process of noticing that a stimulus is there, while perception is the process of figuring out what the stimulus means. For example, when we see something, the visual stimulus is the light energy that comes from the outside world, and our eyes are the sensors. This picture of the outside world becomes a thought in the visual cortex of the brain. Because the image of the world outside of our eyes is projected on our retinas, we can interpret this image and build a model of the three-dimensional world. Although sensations are the foundation of our perceptions, not all sensations result in perception. Only those sensations that we pay attention to are further perceived. In fact, we frequently fail to notice stimuli that are relatively constant over long periods of time, this is known as sensory adaptation. For example, suppose you're working late at night on your psychology journal and you hear a fan creaking. Even though the creaking sound is still present and affecting the auditory sensory receptors, you become less aware of it as you begin writing your journal. The fact that you no longer perceive the sound, demonstrating sensory adaptation and the fact that while sensation and perception are related, they are distinct.

Fundamental principles and theories that apply to any perceptual system will be discussed in detail in this section of the book. The capabilities of visual, auditory, and somatic perceptual processes, as well as the influence of fundamental principles on perceptual experience, will be discussed in greater depth.

1.1.2. PERCEPTUAL REPRESENTATION OF THE PHYSICAL WORLD

Perception may be classified as internal or external. Our bodies communicate with us through internal perception, which tells us what is going on in our bodies. For example, it conveys us our emotions, whether we are feeling sad, happy depressed. It also communicates the pain, pleasure felt on different parts of our body, such as when you know you realize you are having a headache. On the other hand, external perception is the ability to perceive the world outside of our bodies through our senses (sensory perception). For example, perception of colors, shapes, textures, musical tunes etc. Sensory processes and their dynamics are becoming better understood with expansion in the field of cognitive psychology.

According to cognitive science, perception is a cognitive process in which information processing is used to transfer information into the mind, where it is associated with other pieces of information. A central question is whether our senses receive sufficient information to accurately represent the physical world, and if not, why not? The simple answer is 'no,' because our sensory organs have limited ranges. According to Pizlo (2001), there is a deeper information-processing issue known as the inverse-problem that explains why even the best sensory organs cannot provide an accurate representation of the physical world. This problem can be described as follows: Three-dimensional objects are perceived as two-dimensional when they are projected onto our eyes. Due to their two-dimensional nature, these pictures cannot provide information to describe the exact three-dimensional world that exists in reality. Because of this, the images have lost a dimension, and there is no way to reverse the image creation process from two-dimensional images to a three-dimensional scene.

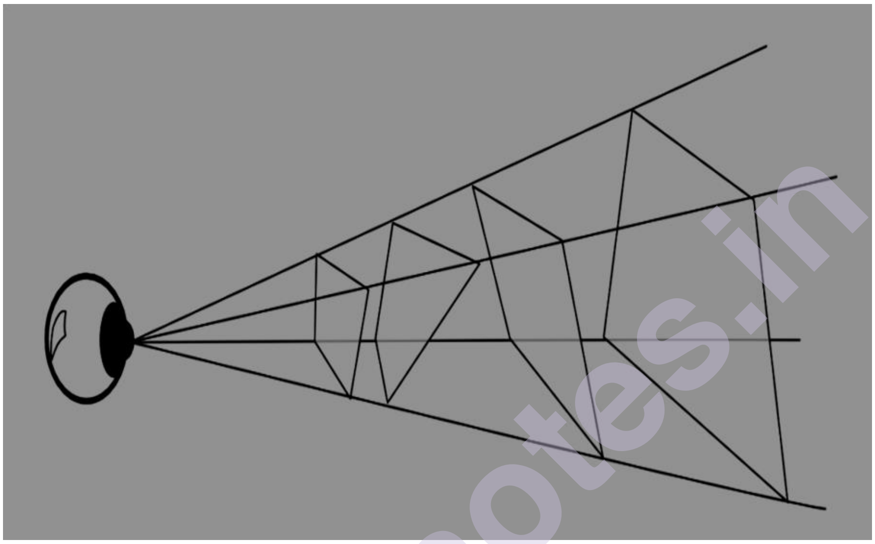


FIGURE 1.1. The same image can be produced by a variety of shapes. It is possible to create the image of a triangle with sides of equal length by arranging a lot of number of possible triangles in a specific way, provided that they are oriented in a specific way. A good example of this is when the image on your retina has lost information and your brain must figure out how to recover that information. (source: Gilhooly; Slehar).

In the previous paragraph, we said that perception doesn't always give us an accurate picture of the world because of the inverse problem and the fact that we lose information when we see. The fact that most of us do well in most of our interactions with the physical world shows that our perceptual systems have found ways to get around theoretical restrictions on processing power.

1.2 THEORETICAL APPROACHES TO PERCEPTION

Our sense organs like the eye, ear, and nose help us gather information from the outside world. Each sense organ in the body is part of a sensory system that receives and sends information to the brain. Psychologists are baffled by how sense organs' physical energy is used to make sense of the world. People use their senses to determine the appearance of trees, buildings, vehicles, sounds, tastes, and pungent odors. There is significant disagreement among psychologists about the extent to which perception is influenced directly by the information available in the environment. A number of researchers have argued that perceptual processes are not simple and that they are influenced by the expectations and prior knowledge of the one perceiving them, in addition to information contained in the stimulus itself. There are two theoretical approaches to explain the process of perception; i. bottom-up approach and ii. Top- down approach.

1.2.1. BOTTOM-UP APPROACHES TO PERCEPTION:

Bottom-up processing involves transforming the original sensory input into a final representation through a series of transformations that continue indefinitely .Bottom-up processing is when perceptual mechanisms work on their own to build more complex representations. In other words, bottom-up processing is characterized by perceptual systems that may construct progressively sophisticated representations.

Bottom-up processing occurs as new sensory information is received by our sensory receptors, and it does not require the use of prior knowledge or experiences .The bottom-up process is when information is transmitted "up" from the stimuli, through the senses, to the brain, which then interprets it "passively." It's called "bottom-up processing," or "data-driven processing," because the processing of information starts with what the environment looks like. Perceptions are built from sensory input. For example, When you are reading a book, you read the first word, then second then third and finally the whole sentence is perceived by putting together all the words perceived till now.

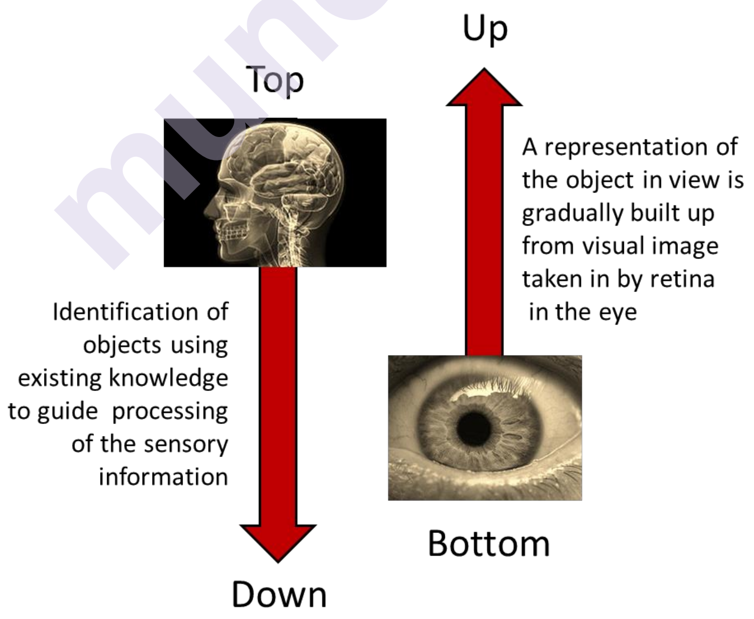


Fig.1.2. Models of Visual Processing

Source: Owlcation, CC0 Public Domain images, via Pixabay

A. TEMPLATE MATCHING /EXEMPLAR THEORY:

Template matching theory explains that, patterns or templates of everything we've ever seen are stored in our memory banks. An object is compared to these examples until we find a match. Template theories assert that patterns aren't really analyzed at all, but rather that templates are holistic entities that are compared to input patterns in order to determine how much overlap there is between the two sets of patterns.

Template matching is effective in pattern recognition machines that read letters and numbers from standardized, restricted contexts, example cheque scanner machines.However, template matching theories come with their own flaws. It is difficult to match templates when the background and illumination are changing as well as when the scale or size changes.

For example, one might not be able to read using template matching even the 26 letters in English if the shapes, sizes, or orientations of the letters were a little off.

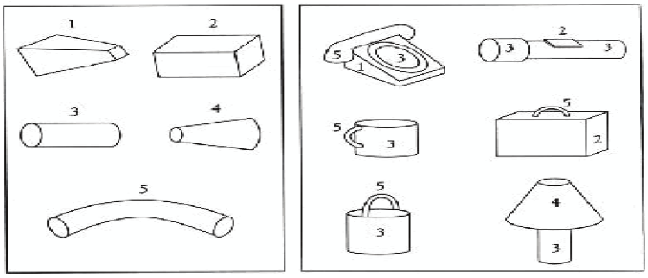
B. PROTOTYPE THEORY:

According to prototype theory, instead of storing a large number of exemplars or rigid templates, we instead store a prototype, which is similar to the average of an object in terms of size, shape, etc. We compare a perceived object to each of these prototypes until the closest match is discovered.

Rather than having a set of predefined templates in our minds, Rosch and Rosch (1973) proposed that we categorize what we perceive by referring to prototypes. Similar to templates in that they symbolize outlines or ideas of what an object should look like, prototypes, unlike templates, rely on best-guesses when various features are in place, as opposed to templates, which require an exact match. For example, a prototype of a bird would include something that has wings and flies.

C. FEATURE ANALYSIS MODEL:

This theory, which was first proposed by Irving Biederman (1987), states that humans recognize objects by breaking them down into their basic 3D geometric shapes, which are referred to as geons (i.e., cylinders, cubes, cones, etc.). Similarly for speech perception we can have phonemes that make up the actual word.



(fig. 1.3. Source: Therriault, David. (2011). On the Future of Object Recognition: The Contribution of Color. 10.5772/15458).

In accordance with this theory, the visual system breaks down incoming stimuli into their constituent elements and processes the information. For recognition purposes, some characteristics may be more important than others. All stimuli have a unique set of characteristics that distinguish them from one another.

In her famous 1969 paper, Eleanor Gibson (1969) describes how children learn the alphabet perceptually. She asserted that perceptual learning took place as a result of the discovery of distinguishing characteristics between letters. Children who are first presented with a "E" and a "F" may not be aware of the differences between the two. The lower horizontal line is the most distinguishing feature present in the E but not in the F.

Feature-matching theories postulate that we break down visual patterns into a set of critical features that we then attempt to match against memory-stored features. For instance, I've memorized that the letter "T" consists of one horizontal line and one vertical line, whereas the letter "Y" consists of one vertical line, two oblique lines, and one acute angle. I possess a similar amount of stored knowledge about the remaining letters of the alphabet. When I am presented with an alphabet letter, the recognition process entails identifying the types of lines and angles and comparing them to previously stored information about all alphabet letters. If I am presented with a "T," as long as I am able to identify the characteristics, I should recognize it as a "T," because no other letter in the alphabet shares this combination of characteristics. Oliver Selfridge's(1959) Pandemonium is the most well-known example of this type.

Advantages of feature models is that the whole-parts problem is solved using a feature list approach by including the parts as attributes of the whole. Example; features of cat's face include having two eyes, having a nose, a mouth, whiskers, whisker pads, and so on. It appears that the 3-D problem can also be solved by the use of 3-D features like spherical, pyramidal as easily as 2-D features like circular, triangular.

1.2.2 TOP-DOWN APPROACHES TO PERCEPTION:

When psychologist Richard Gregory introduced the concept of top-down processing in 1970, it was revolutionary at that time. He asserted that perception is a positive experience. To correctly interpret what we perceive, we must rely on the context in which we perceive it as well as our high-level knowledge of the subject matter. Perception, according to Gregory, is a process that involves hypothesis testing. Between the time visual information reaches the eye and the time it reaches the brain, he asserted that approximately 90 percent of it is lost. As a result, when we see something for the first time, we can't rely solely on our senses to comprehend it. We make hypotheses about the meaning of new visual information based on our existing knowledge and what we recall from previous experiences. Assuming that our hypothesis is correct, we make sense of our perceptions by actively constructing them from a combination of the information we receive through our senses and the information we already know about the world. If, on the other hand, our hypothesis is incorrect, it may result in perceptual errors (Vinney, 2021).

A. PERCEPTUAL LEARNING:

Perceptual learning happens when you get more and more practise distinguishing between two or more things that were previously hard to tell apart. Perceptual learning is the process of changing perception through practise. J. J. and E. J. Gibson (1955) used coil-printed card to demonstrate this phenomenon. There was an original image and several copies of that image with slight variation in it. Copied and original cards were mixed together and presented to participants. Then they showed the original cards. This process was repeated until only the original cards are recognized by participants. They discovered that the errors were due to the other cards' similarity to the original cards. Participants seem to notice more about the figure over time, and this perceptual learning leads to the correct response only.

B. THE WORD SUPERIORITY EFFECT:

Reicher (1969) studied the word superiority effect and the context effect. IN these experiments the participants must identify which of two letters is displayed on the screen. Participants saw either words, nonwords, or single letters for a short time, then two letters were shown to them. They had to figure out which of the two letters was in the first stimulus. For example, people might see the word "LAKE" briefly in a "word" trial, then the letters I and A would be shown as options and they had to identify correctly which of the letter was presented. Then in non word condition KLAE might show up before the letter options, and "A" might show up in single letter condition. Results showed that people were more quickly able to identify the letter in "word" trials than in single-letter trials. As a result, the researchers noticed the letter context effect.

C. THE CONNECTIONIST MODEL OF WORD PERCEPTION:

Feldman and Ballard (1981, 1982) coined the term "connectionist models." The term is used in these papers to refer to a class of models that compute using connections between simple processing units. Parallel distributed processing, or PDP models, is another term that has been used to describe connectionist models by McClelland Rumelhart in 1986. PDP models are connectionist models that emphasize the idea that processing activity is the result of processing interactions between a large number of processing units. In connectionist models, processing occurs as a result of the evolution of activation patterns over time. Connectionist models or Parallel Distributed Processing (PDP) models, are commonly used to figure out how humans think about perception, cognition and behaviour. These models can also be used to figure out how humans learn, store, and retrieve information from their memories. McClelland and

Rumelhart has given this model and this model has several "levels" or systems for figuring out words and letters. Letter detectors can detect letters on basis of features for example, all rounded letters like C, O, Q which have curves are different from X, T or L. Word detectors are also turned on based on their likelihood. The word superiority effect is strong because word detectors work poorly with only one or two letters in the text. When there are multiple letters or a word, detectors work better.

Connectionist models are inspired by how the brain processes information. A neuron is activated which then passes the electric message to the synapse which then transfers it to next neuron and the process continues. Thus each unit transmits its activation level to other units connected to it in the network.

Evaluation of both these models

The way people see the world is based on light reflecting off surfaces and entering their eyes. Their brain then processes the raw data into perceptual awareness. Following this formula, students learn about perception as it progresses from raw data of light to biological response of photoreceptors to more complex processing of edges and objects in the brain. This is known as bottom-up processing. Top-down processing, on the other hand, occurs when people's expectations, emotions, and physical bodies have an influence on their perception of the world. In order to demonstrate the distinction between the two types of information, consider the process of recognizing a strawberry. When the individual surface dimples are processed from the bottom up, they organized into a texture that can be combined with perception of the heart shape and the pink colour, can be recognized as a result of the combination of these separate processes. Starting out with an expectation of what we're looking for is critical in top-down processing, and this knowledge influences lower-level processes that interact with colour, shape, and texture processing. A fundamental difference between bottom-up and top-down processing is the belief that our experiences are a direct result of the sensory input we receive through our eyes, ears, or skin. Bottom-up processing holds that our perceptions are unaffected by what we expect to see, hear, or feel.

When we think about processing sensory information, we think about it from two different perspectives: from the bottom up and from the top down. People can argue about whether processing is done from the bottom up or from the top down. For example, if the perceptual input is clear, bottom-up processing would be more important than top-down processing, which is more important when the perceptual input is unclear. It can be seen that the two can work together, like when Kawano and his group measured the response of visual neurons in monkeys. Face data could be encoded and sent faster than other data (Sugase et al., 1999). They claim that an early representation of a face can quickly send messages to parts of the brain that make them happy or sad. A system like this could be useful for quickly determining whether someone is a friend or a foe, happy or angry, and then using that information to guide how other factors like identity are interpreted after it is received.

1.2.3. PERCEPTUAL ORGANIZATION: LIKELIHOOD PRINCIPLE

Perceptual processing is based on the likelihood of an object or event occurring. This idea has a long history, dating back to Helmholtz's discussions in the 1800s about unconsciously inferring things that haven't actually happened (Helmholtz & Southall, 1962). Perceptual input is typically not rich enough in information to uniquely identify what will be perceived, as previously stated. Thus, we need something else to be able to figure out what the world is like. According to the likelihood principle, a statistical perspective is appropriate for evaluating our perceptual input in order to ascertain our experience. A computational theory called Bayesian Decision Theory provides one statistical approach to perception (Geisler & Kersten, 2002; Jazayeri & Shadlen, 2010; Mamassian & Landy, 2010; Mamassian et al., 2002).

In Bayesian Decision Theory there are three components involved in answering this question. The first is the likelihood, which represents all of the uncertainty in the image. The greater the number of scenes that match the image, the greater the uncertainty. The second component is the prior, which represents one's knowledge of the scene before looking at the picture. The stronger the prior, the less vulnerable one is to the uncertainty of likelihood. Finally, the decision rule is the third component. This includes interpretation of what is scene considering onlooker's objective and task at hand. For example, consider creating a cat detector to search for cats online. Our (fictitious) cat detector looks for fluffy tail. Where we look for a cat image on the internet varies. Assuming we're on a cute cat website, the large prior suggests a cat. A final variable is allowed. For example, if we urgently need a cat photo but a website only has fuzzy and ambiguous animal photos (high likelihood and high prior). We may visit an unlikely website for fun or a new perspective (Gilhooly,2014).

It's amazing how our senses work together to perceive the dazzling array of sights, sounds, smells, and tastes. Our eyes and ears detect light and sound. Skin senses touch, pressure, heat, and cold. Our tongues respond to food molecules and our noses to air scents. Additionally, there are additional senses that enable us to perceive things like balance (kinesthetic sense), time, body position, acceleration, and internal states. The human perceptual system is hardwired for precision, and people are very good at using the vast amount of information available to them (Stoffregen & Bardy, 2001).

Psychophysics studies the impact of physical stimuli on sensory perception and mental states. Gustav Fechner (1801–1887), a German psychologist, established psychophysics by studying the relationship between stimulus strength and detection ability.

Fechner and his colleagues developed measurement techniques to help determine human sensory limits. The ability to detect very faint stimuli is critical. The absolute threshold of a sensation is the intensity of a stimulus that an organism can barely detect.

1.3. DIFFERENT RECEPTORS IN THE BODY

SENSE MODALITY	LOCATION	RECEPTOR	TYPE OF RECEPTOR	STIMULUS
visual	eyes	Rods & cones	photoreceptors	light
auditory	ears	Auditory hair cells	mechanoreceptors	vibrations
Haptic/tactile	skin	Pacinian corpuscles, free nerve endings	Mechanoreceptor, thermoreceptor	Pressure, pain, warmth, cold
olfactory	nose	Olfactory cells	chemoreceptors	Chemicals in the air
gustatory	tongue	Taste buds	chemoreceptors	Chemicals in food
Vestibular system	inner ear	Crista and macula	mechanoreceptors	Tilt or motion

(Table 1.1. Distribution of sensory receptors and their types)

People differ in their internal makeup and life experiences, which help to shape their own information processing systems, so it's impossible to pin down how the brain uses its senses to make sense of the world. Perceptual bi- or multi-stability is a perceptual phenomenon that can help. Qualitative changes in perceptual experience and individual differences in perceptual behaviour can help us understand how people group things together and make decisions. While multiple senses can be activated simultaneously, it is unclear whether these switches are controlled by a central mechanism or by modality-specific systems.

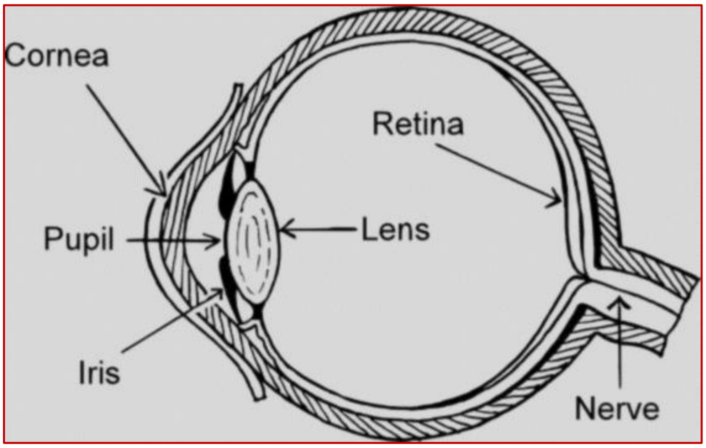
We will begin by discussing the various senses individually, and then we will discuss how information is combined across senses. The fact that talking about the senses separately makes it easier to understand and is also in line with the idea that perceptual systems are organized in a modular manner.

A. VISUAL SYSTEM:

The process of seeing begins when light falls on the eyes, triggering the transduction process. If you look at something, light rays from it pass through your cornea, which is a clear, dome-shaped structure that covers your eyes and lets the light pass through. They will then enter a black hole called the pupil.

The size of your pupil is controlled by the iris i.e. the part of your eyes, which is coloured. It lets your pupil get bigger when you're in a dark place so as much light as possible can get in. In a bright place, your eyes don't get too much light. After that, the light rays are bent so that they go right into your lenses. Once the light rays reach the back part of your eyes, the retina will then convert them into nerve impulses, with the assistance of light-sensitive photoreceptors. (The retina contains two types of photoreceptors called rods and cones). The optic nerve will then deliver these signals to your brain, which translates them into the images you see. An eye with normal vision will focus images perfectly on a small indentation called the fovea, which is a part of your retina, the light-sensitive lining on your eye's back. The fovea has a lot of special cells that can see light. These photoreceptor cells, or cones, are light-detecting cells. They are called this because they have cones on them. A type of photoreceptor called a cone works best when there is a lot of light. Using cones, you can get a lot of information about where things are and how they look. They also have a direct impact on how we can see colour.

During the night, rods, another type of photoreceptor, are found in the rest of the retina. The fovea, where images are usually focused, has a lot of cones. We are able to see in dimly lit places and on the periphery of our visual field because rods are special photoreceptors that work well in low light. Even though they don't have the spatial resolution and colour function of cones, rods are still important for our vision and our sense of movement on the periphery. Night blindness occurs when your rods do not efficiently convert light into nerve impulses.

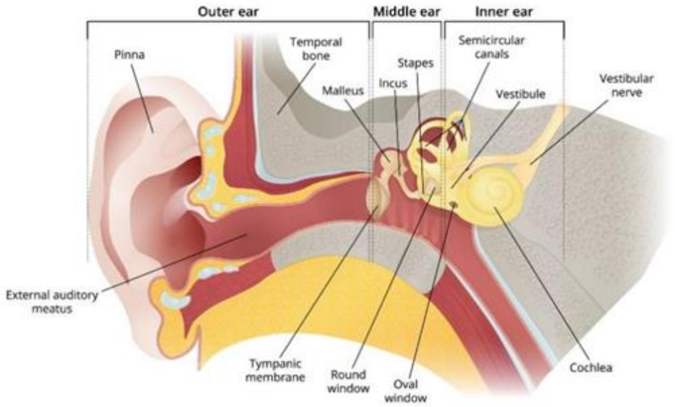


(fig. 1.4. structure of eye)

The primary visual cortex, also known as V1, is an important part of conscious visual processing. V1 plays an important role in visual perception, and patients who have had damage to V1 usually have problems with their vision. These problems can range from problems with specific aspects of vision like depth perception to complete loss of conscious awareness of visual stimuli. The primary visual cortex is located in the occipital lobe of both cerebral hemispheres. From the primary visual cortex, there are two main ways to process visual information that go into the occipital cortex and on to other parts of the brain.One way from the visual cortex to the temporal lobe is called the "ventral stream," and it is used to figure out what objects are in the visual world. Another pathway, called the dorsal stream, goes from the visual cortex to the parietal cortex and is used to figure out where things are in the visual world. This pathway is used to figure out where things are. The ventral stream is in charge of the processes that tell us what an object is, such as its shape and size, however, the dorsal stream is responsible for helping us understand what to do with an object once we have it.

B. AUDITORY SYSTEM

In light of the seemingly limited sensory input our ability to detect, localize, and identify sounds is truly remarkable. Between 20 Hz(Hertz) and 20,000 Hz, the human auditory system is able to hear sounds.The peripheral auditory system is made up of the outer, middle, and inner ears, as well as the auditory nerve. And the central auditory nervous system is made up of the brainstem and brain. Hearing and auditory perception are controlled by the peripheral and central nervous systems working together. The encoding of auditory information begins in the ear's cochlea and then transmitted to the primary auditory cortex, a part of the brain.The basilar membrane contains hair cells in the cochlea. Hair cells respond to sound pressure by vibrating, sending a signal along the auditory nerve.There are many factors that go into how the pitch of a sound is perceived. One way that pitch is encoded is that different parts of the basilar membrane are sensitive to different pitches of sound.



(fig. 1.5. Image source: Madeleine Burry; Healthy hearing)

Diagram depicting the anatomy of sound. The human ear has three main sections: outer, middle, and inner. Sound waves travel from the outer ear i.e. from pinna to the middle ear, where the eardrum is located. Then from middle ear to inner ear where cochlea then converts those waves into electrical signals and these signals are then passed on to brain which helps in identification of sound.

(i) PROPERTIES OF SOUND:

Let us analyze the different properties of sound. So there are 5 properties of sound; (i) Frequency, (ii) Amplitude, (iii) Timbre, (iv) speed of sound waves, and (v) Duration.

i. **Frequency:** The frequency of sound waves is measured in hertz (Hz).Humans can normally hear sounds between 20 Hz and 20,000 Hz. Infrasound is defined as sounds below 20 hertz. Humans cannot hear infrasound. Ultrasound refers to sounds above 20,000 hertz. Also above 20,00 hz humans cannot hear the sound. An example of low frequency sound is sea waves, wind sound etc. High frequency sound examples are sound of a whistle, bursting of crackers etc.

ii. **Amplitude:** The strength or level of sound pressure is referred to as the amplitude of sound. A wave's amplitude determines its energy carrying capacity. A high amplitude wave carries a lot of energy, while a low amplitude wave carries little. One way to measure a wave's intensity is to look at how much energy passes through it per unit time. The amplitude of the sound wave increases the intensity of the sound. Sounds with more intensity are heard louder. Sound intensity is commonly expressed in decibels (dB).

iii. **Timbre:** Timbre is a characteristic of sound. It is what distinguishes two distinct sounds from each other. For example if one is playing national anthem on flute and other person on harmonium , timbre helps to identify the difference in instruments even when they play the same musical note. In other word timbre means quality of sound.

iv. **Speed of sound waves:** Sound waves travel through a medium.Speed of sound waves is determined by the properties of the medium through which it travels. Sound waves travel through air, water, metal, wood, etc.Sound vibrations are carried more effectively by light materials than anything else. The elasticity of a material is also important for sound transmission, less elastic materials, such as rubber and paper, are more likely to absorb sound rather than transmit it.

v. **Duration:** duration refer to the amount of time for which the vibration of sound lasts. It can tell long sounds from short sounds. It has to do with persistence, which is a scientific term for how long the sound wave lasts.

So these were some of the properties of sound that would decide upon how our brain receives signal and how we are able to identify different sounds of objects.

(ii) ROLE OF AUDITORY CORTEX

The auditory cortex is located in the temporal lobe. It is made up of a lot of different cells that connect to each other in an intricate way to facilitate processing of auditory information (Moller 2013). The auditory cortex is the part of the brain that makes us aware of sound and helps us understand and make sounds that are meaningful. It is made up of a complex network of internal and external connections (Hackett 2015).Higher-level auditory processing, such as recognizing speech-specific aspects of sound, is thought to be aided by the auditory cortex. Damage to the auditory cortex can cause problems with different aspects of auditory perception.

Receptive aphasia and amusia may be caused by damage to the auditory cortex and other parts of the brain that deal with hearing. Amusia, also known as tone deafness, is a condition that makes it hard to hear small changes in the pitch of melodies (Ayotte et al., 2000; Peretz et al., 2002). People who have amusia can find music to be a messy mix of sounds that they find even unpleasant to listen to. In some cases, amusia is a short-term side effect of a stroke, but it can sometimes last for a long time (Sarkamo et al., 2009).

C. SOMATO SENSORY SYSTEM:

Proprioception, vestibular sensation, and touch are all subsystems of somato perception. Proprioception and vestibular sensation help us understand our body's position in space. Both are important in the generation and control of action. Touch collects information about objects in the world, similar to how vision helps us recognize objects. Our hidden sixth sense is known as proprioception. Our muscles and joints have sensory processors that process sensory information as our bodies move. Proprioceptive feedback refers to the stretching of our muscles and the changes in joint position that occur when we move. This provides our brain with information about the current location of our arms, legs, and body, which is critical for coordination. For instance, when you are awaken to the sound of an alarm next to your bedside, you reach out to the alarm while your eyes are still closed in order to silence the hammering tone. The proprioceptors communicate to the brain and inform about where our hand is to brain.Walking is another example. You don't need to look at your foot to lift, move, and lower it. Proprioceptors constantly send information to the brain about the position of your hip, knee, ankle, and toes. This ensures proper movement (Kim Griffin).

Our ability to maintain balance and body posture is aided by the vestibular sense. The vestibular system keeps track of your body's balance and movement. The vestibular senses (body rotation, gravitation, and movement sensations) originate in the inner ear; the sense organs are hair cells that send out signals via the auditory nerve. For normal movement and balance, the vestibular system is required.

Touch, also known as tactile perception, is one of the somatosensory senses, which also includes the ability to perceive pressure, stretch, and vibration among other things. Pressure is linked to the senses of itch and tickle, and pain is linked to burn injuries. Mechanical, chemical, and thermal energy stimulate touch receptors. Pressure appears to be the only touch sense with distinct receptors.

Ronald Melzack and Charles Patrick Wall (1965) proposed a revolutionary theory of pain, known as Gate control theory of Pain. Nociceptive pain stimulates primary afferent fibers, which then travel to the brain via transmission cells. Pain perception is enhanced by increased activity of transmission cell whereas decreased activity on the other hand leads to reduction in perceived pain. In the gate control theory, a closed "gate" blocks the input to transmission cells which reduces pain sensation. On the other hand, when the input passes through the open "gate" the sensation of pain is perceived.

In conclusion, proprioception and fine touch are usually lost when the somatosensory cortex is damaged. This can cause problems with knowing where on the body one is being touched or even being aware of being touched at all (Head & Holmes, 1911; Longo et al., 2010).Debate is still going on about how to treat the often painful sensations that can happen with phantom limbs. As a result, it's thought that one way to better understand the condition is to find out how the adult cortex remaps the parts of the somatosensory cortex that are no longer represented (Ramachandran & Hirstein, 1998).

D. MULTI SENSORY SYSTEM:

We've talked about the senses and their processing channels separately so far. We, on the other hand, do not perceive the world as a collection of disparate bits of data, but rather as a unified whole. As a result, how we combine information within and across senses is a critical issue in perception. There are a lot of different theories about how the perceptual system might be able to combine information. One of them is called the "modality appropriate hypothesis," and it says that for each physical property in the environment, there is one sense that is better at estimating it than the other senses. This sense will always be the one that dominates bimodal estimates of the property. A study by Bertelson and Radeau (1981) shows that vision dominates on spatial tasks, while hearing dominates on temporal tasks (Gebhard and Mowbray 1959; Recanzone 2003; Shipley, 1964; Welch et al., 1986). These studies show that the modality appropriate hypothesis is correct.

1.4. SUMMARY

In the beginning of the chapter we saw, that in order to perceive something, we must go through a series of steps that begin with environmental stimuli and culminate with our interpretation of those stimuli. Perception is the process of making sense of sensory data that is presented to the brain.

Perception can be divided into two categories: internal perception and external perception. Our bodies communicate with us through internal perception, which provides us with information about what is going on inside our own bodies. For example, it conveys our emotions, whether we are depressed, happy, or indifferent to the situation. It also conveys the sensations of pain and pleasure experienced by different parts of our bodies.

When using bottom-up processing, you are transforming the original sensory input into a final representation through a series of transformations that can last an indefinite amount of time. Bottom-up processing, also known as data-driven processing, is the process by which perceptual mechanisms work independently to construct more complex representations of the world around them.

Template matching, prototype model and feature analysis model are some of the bottom-up approaches to perception. The template matching theory is the most fundamental theory of human pattern recognition. It is a theory that assumes that each perceived object is stored in long-term memory as a "template." To ensure an exact match, incoming data is compared to these templates. In other words, all sensory information is compared to multiple representations of an object in order to form a unified conceptual understanding.

Prototypes are similar to templates in that they symbolize outlines or ideas of what an object should look like. Prototypes, unlike templates, rely on best-guesses when various features are in place, as opposed to templates, which require an exact match.

According to feature analysis, we notice individual characteristics, or features, of every object and pattern we come across. According to this theory, the visual system processes information by breaking down incoming stimuli into its constituent elements. Some characteristics may be more important than others for recognition purposes. Each stimuli has its own set of characteristics that set it apart from the others.

Top-down processing is an important perceptual theory. The theory proposes that sensory information processing in human cognition, such as perception, recognition, memory, and comprehension, is organized and shaped by prior experience, expectations, and meaningful context.

Perceptual learning, word superiority effect, connectionist model of word perception are some of the top down approaches to perception. Perceptual learning is the process by which sensory systems improve their ability to respond to stimuli through experience. The more perceptual learning that occurs, the more connections are formed in the brain. The more perceptual learning you undergo, the faster the process of perception occurs. With sufficient perceptual learning, the brain begins to recognise patterns, knows where to focus its attention, and gains confidence in its ability to make sense of stimuli.

According to the word superiority effect, when written stimuli are deteriorated by noise or brief presentation, letters presented in context of words are reported more accurately than single letters and letters presented in context of non-words.

The likelihood principle says that the way people see things should match up with the most likely way things will look later on. Simplicity is one of the main ideas in Gestalt psychology. It says that perceptual organization should be as simple as possible.

We have seen different sensory modalities such as visual, auditory, somato sensory and multi-sensory. Though each of them work independently but instead of perceiving the world as a collection of disparate pieces of information, we see it as a unified whole. Therefore, perception is highly dependent on how we combine information from different senses and from different sources. Numerous hypotheses have been proposed to explain how the perceptual system may be able to combine information from different sources of information.

1.5. QUESTIONS

Q.1. Discuss the nature of perception

Q.2. What are the different theoretical approaches towards perception?

Q.3. Describe in detail the bottom-up approaches to perception

Q.4. Explain in detail what involves top-down processing?

Q.5. How does human perceptual system work?

Q.6. Describe in brief likelihood principle of perception.

Q.7. Write notes on

1. word superiority effect
2. perceptual learning
3. Top-down approach
4. bottom-up approach
5. visual system
6. auditory system
7. somato sensory system

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2

PERCEPTION: RECOGNIZING PATTERNS AND OBJECTS - II

Unit Structure

2.0 OBJECTIVES

After studying this Unit, the learner will be able to understand:

- The process of recognition across various stimuli.
- What is social perception and how it takes place?

In the first unit of perception, we tried to understand the nature of perception and how the fundamental principles and theories are applied to any perceptual system. The capabilities of visual, auditory, and somatic perceptual processes were discussed in greater detail, as well as the influence of fundamental principles on perceptual experience.

In this module we shall learn about how recognition of objects and events occurs. The perceptual process enables us to experience and interact with the world in appropriate and meaningful ways. Through this unit we will explore and learn how objects and events are represented and understood across different conditions. We shall also learn the process of social perception, of how we understand and interpret behaviour of other individuals.

2.1 RECOGNITION

Recognizing an object involves comparing an object representation to a previously stored internal representation, which is a simple way to explain how recognition works. The object is recognized if the perceptual representation matches a memory representation. Many possible recognition schemes have been tested, but it has proved difficult to capture human recognition capabilities. In terms of human recognition, the key capability that distinguishes it is its ability to evaluate many different perceptual inputs and recognize these different inputs as being the same thing. Consider how many different ways a simple letter 'A' can be written to get a sense of the issue. When you consider all the possible transformations of these various versions of 'A,' such as rotation and scaling, shrinking or enlarging, the capability becomes even more impressive.

Fig 2.1. Numerous shapes may share the same identity. All of these figures represent the letter 'A'.This uniform property of the figures that allows them to all be recognized as ‘A' is difficult to quantify.

In order to describe how individuals are able to detect the objects based on their features, we will look at the feature analysis model. Feature analysis, usually involves breaking down an object into a set of component features that can be compared to a library of other similar objects. Throughout this library, each object is described by a distinct set of characteristics. One such model is given by Oliver Selfridge known as **Pandemonium model** of letter perception in 1959.

The Pandemonium model is used to understand how humans organise their perceptions of what they see, into pictures and meaningful objects. In Pandemonium model demons represent specific neurons. These demons are distinctively named as (i) feature demon, (ii) cognitive demon and (iii) decision demon. These demons express three distinct modes of perception. Feature demons construct and encode distinctive features of the letters. In the above example of ‘A’, feature demons construct and encode the horizontal or slanted line of ‘A’, which is also similarly constructed for forming the letter ‘X’ (slanted lines) and letter ‘T’ (horizontal line). Once feature demon has constructed the component features of ‘A’ then next there are cognitive demons which encode for certain letters after the feature demons have built one. Finally, decision demons are what our brain actually sees as a result of the neurons' or demons' collective decision. In this example the decision will be the recognition that is letter ‘A’.

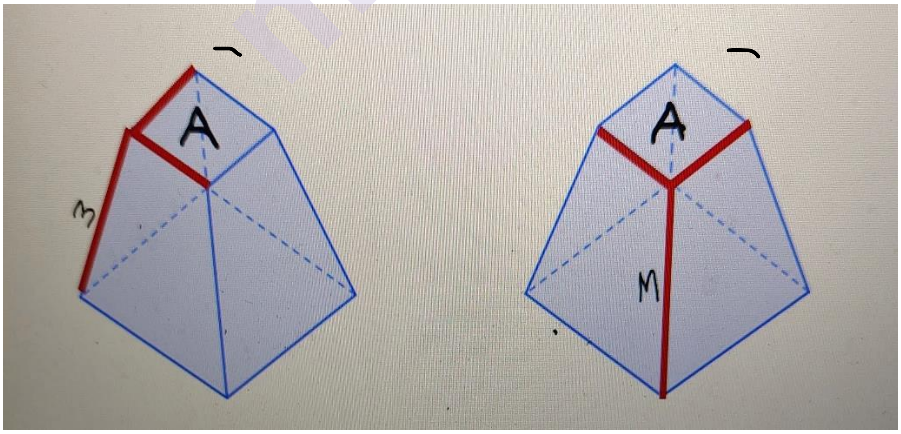
2.1.1 Recognition of Objects

We will examine two instances of object recognition, the first of which involves the visual system and the second of which involves the somatoperception system. Despite the fact that they are diametrically opposed in many ways, they both illustrate the process of selecting characteristics for recognition. There must be a good understanding of the features that are used and how they are found and computed in order to recognize objects.

(A) OBJECT RECOGNITION THROUGH VISUAL SYSTEM:

Object identification is the primary goal of visual processing and a necessary pre-requisite for interacting with and reasoning about the world. Thus, the question of how we recognize objects is both perceptual and cognitive, uniting what are frequently considered to be distinct disciplines**.**

(i) The majority of objects in the natural world are three-dimensional, which presents a challenge to vision because it must recognize a three-dimensional object using only the two-dimensional information on the retina. Visual objects have certain invariant (or non-accidental) properties. These properties include the manner in which lines meet at vertices to form specific configurations such as T or Y, also referred to as line junctions and line co-terminations (refer fig. 2.2).



(Fig 2.2. Truncating an edge with a surface makes a 'Y' junction that is the same from any angle. Binford (1981) showed that if an edge 'm' was cut off by a surface 'A', the image would show a 'Y' junction. There are two different ways to look at the edge 'e' that is cut off by 'S' in the figure.

Source: Adapted from Binford, T. O. (1981). Inferring surfaces from images. Artificial Intelligence, 17(1), 205–244.)

Binford (1981) published a seminal paper that outlined a set of assumptions for relating lines in an image or line drawing to the possible three-dimensional configurations that caused them to appear. According to one widely accepted model of object recognition, the visual system typically describes objects using view-specific representations, but uses viewpoint-invariant representations. When the world is projected onto our retina and depth is lost, the Y junction will be formed regardless of the angle at which we view the object. There are many ways to look at this relationship, and it's called as a viewpoint invariant relationship. A viewpoint invariant relationship is any property of an object that remains constant regardless of the direction from which we view it.

(ii) Biederman (1987) made significant advancements in the recognition of viewpoint invariant features by naming this phenomenon 'geons'. The recognition by components (RBC) approach, which he developed, was based on the idea that objects could be thought of as being composed of a collection of geons. We have earlier seen in Unit 1 the description of geons and how they help in object recognition. Each individual geon in an object could be identified by its own unique collection of viewpoint invariant properties and all the geons together make it possible for an entire object to be recognized as a whole.

Our perception of three-dimensional objects appears to be chunked into approximately 36 "geons," each of which possesses the critical property of viewpoint independence (Biederman, 1987). This is referred to as recognition by component. Viewpoint-dependent recognition, on the other hand, is based on matching perception with a holistic memory representation. When this happens, we can tell if recognition is faster for common viewing angles than uncommon ones(For example, you can recognize photo of your friend's face faster if it is straight than if photo is shown upside down). On a variety of object recognition experiments, this RBC approach was shown to accurately reflect human performance. One experiment demonstrated that geon recovery was critical for recognition by systematically deleting specific parts of a line drawing. Line drawings were created, and then subsequent versions were created, some of which were deleted at viewpoint invariant regions or elsewhere. When viewpoint invariant information was removed from the regions, performance was found to suffer significantly. Observers identified objects in drawings with viewpoint invariant properties much more quickly. This and other experiments helped to demonstrate the importance of viewpoint invariant relationships and how RBC could account for viewpoint independent object recognition from line drawings.

(*An experiment by Biederman, 1987,where an equal amount of contour was deleted from line drawings, resulted in recoverable or* *nonrecoverable parts. The left column contains intact images, the middle column contains recoverable images, and the right column contains nonrecoverable images- visit link to check the experimental material used https://www.kalocsai.net/research/object/Recoverable.htm)*

(iii) **Multiple Views Theory:** The multiple views theory, asserts that object recognition is fundamentally image-based (Tarr & Bulthoff, 1998). It claimed that object recognition could be achieved by storing representations of a few learned views of the object. Based on these selected views, sophisticated mechanisms could fill in representations of the intermediate views. As a result, when a new view of an object was observed, mechanisms that matched the viewed image to the select and intermediate filled-in versions could recognize it. This method predicted that when objects were viewed from directions that were more similar to the learned views, recognition would improve.

A debate about whether object representations show only one point of view or many different points of view has been the main focus of object recognition research in recent years, but now it seems to be dying down. As opposed to presuming that only structural or view information can be used to identify an object, researchers are now looking into how these properties can be used in an actual situation. A recent study by Foster and Gilson shows that both types of information are important in predicting recognition performance. In fact, it has been demonstrated that humans perform view-invariant recognition of familiar objects, but that they perform view-dependent recognition tasks involving novel objects or unfamiliar object views (Edelman and Bülthoff, 1992; Spech et al., 2001).

Yet another research in the area of visual object recognition was carried out by Ullman and his colleagues in 2002.They used Information theory to show that patches of images with intermediate complexity were the best way to store a set of images for later recognition tasks. When the human visual system analyses shapes and objects, it does so in a series of stages, each of which extracts and analyses stimulus features that become increasingly complex. The image is first represented in terms of simple local features, and then it is represented in terms of larger and more complex features (For example, outline of the tree, its colour etc are local features which then together provide the recognition that the target object is tree). The basic visual task of classification works best with features of intermediate complexity. Moderately complex features are more informative for classification than very simple or very complex ones, and as a result, they emerge naturally from the simple coding principle of information maximization in relation to a class of images. This approach shares with recognition by component the use of a set of informative image features but does not require them to be informative about three-dimensional structure, only that they optimally describe the objects to be recognized.

(B) OBJECT RECOGNITION THROUGH SOMATOPERCEPTIVE SYSTEM

Let us understand how object recognition can take place through somatoperceptive system (skin senses). It can be easily performed by free exploration of an object, with the help of hands. This will activate subsystems of the somatoperceptual system that are responsible for estimating the weight and texture of an object, as well as the position of the body parts that are in contact with the object. These subsystems work together to create haptic perception, which is a type of sensory perception. The example would be when you close your eyes and a friend keeps a birthday present in your hand, by touching the present and recognizing its shape and texture via tactile sensation, you recognize the gift item correctly to be a diary.

Haptic perception (perception by active touching and intentionally exploring the objects and surfaces) begins in early childhood and develops throughout adolescence. To learn about objects, the infant first uses oral exploration. The hands are used to transport objects to the mouth and then as a primary tool for exploring haptic objects. Object manipulation starts with grasping and progresses to more specific manipulation patterns, e.g., fingering, banging that are tailored to the object's physical properties. Later manual manipulation replaces oral exploration or mouthing as the preferred method of object exploration. Ongoing refinement of haptic object recognition and exploration strategies will continue for some time. In the following years, the accuracy of haptic object recognition improves while the complexity of manual manipulation and exploratory strategies increases (Cermak, 1995).According to research, the ability to use cognitive strategies such as visual imagery and verbalization in the cognitive processing of haptic information improves with age as a result of brain development. The link between mental age and haptic object recognition accuracy appears to be linked to intelligence.

Lederman, Klatzky, and colleague studied a number of interesting haptic properties. This research established that a critical component of the haptic system is its ability to rapidly and accurately recognize the attributes of three-dimensional objects. A single grasp is often all that is needed to identify an object using haptic perception, according to research (Klatzky et al., 1985). Global shape, hardness, temperature, weight, size, articulation, and function are just a few of these characteristics. This research resulted in the identification of hand movement strategies used by humans to discover various properties of three-dimensional objects. They termed these procedures as Exploratory Procedures, and reported success rates of 96-99 percent in identifying various object properties using twohanded, haptic exploration. Lederman and Klatzky called them Exploratory Procedures (EPs) and exactly defined an EP as: “stereotyped hand movement that is spontaneously used when extracting a particular object property and is generally optimal (if not necessary) for extracting that property.”

Gibson (1962) presents a theoretical approach to the role of hand movements in haptic perception. The stimulation of the sensory receptors is dependent not only on the specific object that is being touched, but also on the motor activity of the observer. Gibson hypothesizes that when observers are free to explore (active touch), they will make arm movements that increase certain aspects of sensory stimulation while diminishing others. These arm movements are considered to strengthen the sensory influx associated with the particular stimulus quality. As a result, among all the various arm movements an observer may perform, these particular arm movements that are most suited to acquiring crucial information. So, when provided with a stimulus, an observer will begin investigating the object, looking for appropriate stimulation that will allow them to perceive what they are touching.

The more intense the test stimulus is, the less suppression there is. This means that stronger tactile stimuli are all felt, but their subjective intensity is lessened (Williams & Chapman, 2000). If the test stimulus is sufficiently intense, there may be no decrease in subjective intensity when the participant moves during the test.

During movement, the ability to discriminate between pairs of barely perceptible tactile sensations is unaffected. This means that the relative differences between tactile inputs are still there even though their subjective intensity may be lower (Chapman et al., 1987; Post et al., 1994).

VISUAL AGNOSIA AND PROSOPAGNOSIA:

Visual agnosia is a neuropsychological condition marked by severe difficulty with object recognition. It is not caused by abnormalities in early sensory vision, memory, or language function. Visual agnosia, sometimes known as 'acquired' visual agnosia, is a highly heterogeneous condition caused by injury to a normal region or regions of the cortical visual system. Agnosia can also be caused by brain damage in early infants, which is known as acquired 'developmental' agnosia, and it can even be present in cases of 'congenital' agnosia, in which behaviour is impaired probably from birth but there is no obvious neurological damage. Visual agnosia, differs from blindness as in visual agnosia people appear to be able to extract a pretty intact sense of what they see but are unable to give meaning to this percept (Farah, 1990; Humphreys & Riddoch, 1987).

People who suffer from primary visual agnosia may have one or more impairments in visual recognition, but they do not appear to be impaired in terms of intelligence, motivation, or attention. Some people with the condition are unable to recognize familiar objects. They can see objects, but they can't tell what these objects are by looking at them. Touch, sound, and smell can all be used to identify items. Affected people, for example, may not be able to recognize a pen by sight but can recognize them when they hold it in their hands.

Associative visual agnosia has three sub types viz; **achromatopsia, simultagnosia and prosopagnosia**. Achromatopsia refers to total color blindness whereas simultagnosia refers to the inability of an individual to perceive more than a single object at a time. We will be focusing on prosopagnosia, where an individual cannot recognize human faces which may be caused due to occipital- temporal lobe lesions.It is possible for people with prosopagnosia to detect the identity of others based on characteristics like their voice, hairdo or glasses. However, when only the face of a familiar person is shown to them, they fail to recognize it. Prosopagnosia may be under-reported due to the efficacy of alternate identity recognition mechanisms such as voice and hair.

2.1.2 Recognition Of Scenes

Scene recognition is a natural extension of object recognition research. Recognizing a single, precisely depicted object is common in object recognition research. Scene recognition entails seeing an environment, both individually and collectively. Scene recognition is vital for understanding how recognition works in the real world. When observers examine a quick sequence of images, they briefly grasp the gist of each scene but have weak recognition memory for the majority of them (M. C. Potter, 1976). Is forgetting instantaneous, or does some information linger for a little period of time? In order to understand this, Potter conducted research wherein when participants were presented with pictures in rapid succession, then the presentation intervals of 250 milliseconds or fewer were sufficient for participants to reliably determine whether they had seen or not seen a photo in the rapidly displayed sequence(Potter, 1976).Other findings by Kirchner & Thorpe, 2006; Van Rullen & Thorpe, 2001, support the notion that humans are adept at swiftly processing visual scenes.

The eyes are weak at capturing information when not stationary and move every 1/3 second. The eye movement pattern is complex, and not every part of the scene will be fixated (Henderson & Hollingworth, 1999; Tatler et al., 2010; Yarbus, 1967). So, why do we stare at a random photo? Why do we move our eyes? These questions could be best explained by bottom-up and top-down theories. As per the bottom up theories it is believed that novel visual qualities such as brightness, colour, or unusual shape cause particular image regions to become salient, and that this image salience is capturing our eye movements. Eye movements are influenced by our expectations and ambitions, according to the top-down explanation (Rao et al., 2002; Torralba et al., 2006).The sense of vision is not the only source of important information about scene composition. Audio can reveal the distance, location, and number of elements in a scene, as well as the general openness of the space. While the amplitude of the sound wave indicates distance, the timbre of the arriving sound wave also indicates distance. In the same way that the environment absorbs and scatters light to make distant sights appear cloudy, similarly it filters sound waves. The sounds we perceive are a combination of direct and reflected sound waves (echoes).Comparing direct and reflected waves inside is important since walls reflect waves. Even with our eyes closed, we can tell the size of a room by our footsteps. Bats utilize echolocation to explore their environment, and some blind people do too

(Rosenblum et al., 2000; Schenkman & Nilsson, 2010).Auditory scene analysis involves sound stream isolation (Bregman, 1990). For example, bottom-up processing can distinguish between many sound streams. Whereas top-down processes alter our perceptions of the speaker and the circumstance. In addition, language knowledge and expectations help us understand the speaker's words.

2.1.3 Recognition of Events

As we've discussed in our explanation of object and scene recognition, we've treated the visual world as being static and unchanging, while motion and change are present everywhere. How physical objects interact with one another provides us with a classic example of how actions progress through time. In ecological psychology, event perception is defined as changes in layout, changes in surface existence, or changes in colour and texture (Gibson, 1979). The study of event perception has its origins in social perception and the sense of causation. Much of the early studies illustrating the mental creation of situation models of how objects and characters interact in narrative text is also closely related to event perception. While much research on event perception has focused on how humans interpret dynamic visual events in the present, textual and audio descriptions of events have also been employed as stimuli. This discipline has helped us answer critical issues like “How do humans recall everyday things?” “Why do some individuals recall daily experiences better than others?” "What happens when one's expectations about how an activity should go aren't met? What cognitive and neural mechanisms are responsible for putting this new information into the memory trace for that event? Many categories of events can be identified based on motion patterns, according to research from the Michotte and Gibson . This is also true for events that are defined by more complex human actions. Presenting viewers with animations of points on a person's body while that person performs an action is one method for studying the role of motion analysis in action identification.

Another research by Heider and Simmel (1944) found that, when most people watch an animation of independently moving geometric shapes, people attribute intentional movement and goal-directed interactions to the shapes and the attribution occurs in the absence of common social cues such as body language, facial expressions, or speech.

Events can be understood better if the temporal structure of the events is taken into account according to Zacks & Tversky, 2001. The authors begin by analyzing how individuals use event structure in perception, comprehension, planning, and action. Events have both categories and parts and using this method of breaking down continuous activity into discrete events with a beginning and an end, we can better organize our perception of the world around us.According to Schema Theory, the mind is made up of organized mental templates that aid perception and information processing. The Perceptual Cycle Model represents the dynamics of performance in context (Neisser, 1976). As per the Perceptual cycle hypothesis, cognition influences perceptual exploration, but this is altered by real-world encounters, resulting in a cycle of attention, cognition, comprehension, and the authentic world, in which each influences the others.

2.2 SOCIAL PERCEPTION

The study of social perception is important for a number of reasons. Understanding what perceptual information signals social meaning will help us understand human to human interaction at a deeper level. Social Signal Processing(SSP) is a new research and technological domain that aims to provide computers with the ability to sense and understand human social signals (Pentland, 2007; Vinciarelli et al., 2009). Let us understand Marr's computational theory behind social perception. David Marr (2010) focuses on a vision computational theory. He claims that a visual process must go through several steps, each with its own representation of the retina image. The three levels of explanation are designed to aid in the processing of information. His main goal is to distinguish between the three levels of explanation and to provide computation theories. The three levels are computational, algorithmic and implementation level.

At the computational level, the goal is to create a mental representation of visual images; for example, the input could be a person's senses and the output could be his or her actions(Your mom calling out your name - auditory perception , and you responding to her- your action).The computation level attempts to answer the logical question of how information input and output occur.

At the second level which is algorithmic, the system is programmed to convert its output and input. It tries to figure out what algorithms the brain uses to achieve its computational goals. The algorithm level investigates how the brain converts visual information into a mental representation of a three-dimensional image.

At level three which is implementation level, the theory attempts to understand how the algorithm is assimilated into the physical structure of the mind. It attempts to provide an answer to the question of how the system is physically comprehended.

Let us understand what does social perception help us with. Social perception provides us with information about the thoughts, emotions, and internal states of others, and this information is useful in navigating our social world and making decisions (Frith & Frith, 2003).Our ability to explain and predict other people's behaviour by attributing to them independent mental states, such as beliefs and desires, is known as having a 'theory of mind'.

2.2.1 Perception Of Faces

Recognizing and remembering faces is critical for humans. Face perception involves a complex network of brain regions that have been intensively studied by many researchers over the years. Faces are significant sources of social information that we use to identify individual characteristics such as emotion, gender, age, attractiveness, and identity. Face recognition is difficult because, while some aspects of a face, like shape, remain constant over time, others, like lighting, viewpoint, makeup, health, expression, etc., change its appearance. This research has been carried out in conjunction with investigations into how unfamiliar faces are processed, and the findings from these two strands of research have led to the development of accounts that propose qualitatively different forms of representation for familiar and unfamiliar faces, respectively. Since the 1970s, there has been an ongoing interest in how people recognize familiar faces (Bruce, 1979; Ellis, 1975). In one of the research by Hiroshi and Sakurai (2014),it was found that reaction times to identify unfamiliar faces were slower than reaction times to identify personally familiar and famous faces.

Researchers are working to develop automated face recognition systems that can match, and eventually surpass, human performance. Research findings shed light on the types of cues that the human visual system employs to achieve its impressive results, and they serve as the foundation for efforts to artificially replicate these abilities. Functional brain imaging enables non-invasive investigation of the neural systems involved in face perception in the intact human brain. Face perception elicits greater activity in a bilateral region of the lateral fusiform gyrus than nonsense, control, or nonface object perception (Hoffman and Haxby 2000; Ishai et al 1999; Kanwisher et al 1997).According to the classic Bruce and Young (1986) model of face recognition, identity and emotional expression data from the face are independently and concurrently processed. According to Bruce and Young, recalling a person's name requires retrieving semantic information about the individual beforehand. As per this model, the process of face recognition takes place in 3 stages; (i) face familiarity, (ii) retrieval of semantic information,(iii) retrieval of names (Hanley, 2011).Haxby and his colleagues came up with a hierarchical model of how people see faces. The model has a core system with three parts of the brain that help with visual analysis and an extended system that adds to these visual functions.

2.2.2 Perception Of Voice

The voice, like faces, serves as an important cue to our social environment. Despite their different physical structures, face and voice signals carry highly similar types of socially relevant information. Both contain linguistic data as well as information on a variety of personal biological characteristics. For example, one can easily recognize the gender, age, emotion, physical strength of the person. Hence, we may call voice as an 'auditory face'. The acoustic properties of speech may give clues about internal emotional states of the person , also known as "vocal expression of emotion"(Bachorowski et al.). Human fMRI studies have identified distinct regions outside the primary auditory cortex in the superior temporal sulcus (STS) that appear to be sensitive to the human voice (Belin et al.).This temporal voice area has been discovered to respond more actively to human voice sounds than to a variety of other sounds, such as animal vocalizations and various non-vocal sounds.

2.2.3 Perception Of Motion (Biological Motion):

How does social perception of motion takes place? Might be an important question to answer. As social creatures, humans use the movements of others to gauge their own abilities. A person who moves smoothly with coordination is judged as more likely to be attractive, trustworthy, or competent. Experimenters must distinguish between body movement and other properties of the person. The factors such as kinds of clothes, facial attractiveness, haircut, body shape etc., must be eliminated because they add extra information about the person being viewed, only then one will be able to understand how biological motion perception occurs. Gunnar Johansson (1973) filmed actors in dark room with light points on their joints. Then he showed films of these actions with only light points contrasted. An active human form was seen rather than a jumble of random points. These point-light displays can be organized into a perception of a specific human action.

Human gait has been studied for over a century using light strips or points. For example, Marey (1895/1972, p. 60) taped white tape to a walker's limbs. He then studied the walker's lateral movements in front of a camera's stroboscopic traces. For the same effect, other researchers used small incandescent bulbs attached to joints (for a review, see Bernstein, 1967, p. 3ff). This method, called cyclography, produces planar projections of movement cycles over time. This and other methods made human gait one of the most studied complex cyclical movements (cutting et al.).

Another model on movement perception by Giese indicates two parallel pathways, one for the dorsal pathway (specialized for motion analysis) and one for the ventral pathway (specialized for the analysis of form information). They extract form or optic-flow features with increasing complexity along the hierarchy. The feature detectors' position and size invariance increase with the hierarchy. The ventral and dorsal pathways are required for the recognition of normal biological movement stimuli, while the dorsal pathway appears to be required for the recognition of point-light stimuli.

Understanding others' emotions via nonverbal cues is essential for successful social interactions. One brain region thought to be important in recognizing others' mental states based on body language and facial expression is the right posterior superior temporal sulcus (pSTS) (Basil et al.).

2.3. SUMMARY

Perception is the way we perceive the world around us. Understanding the world around us is a set of processes that organizes our senses into an accurate representation of it. As a result, it helps us understand how behavior like navigation and recognition are influenced by our mental world.

People are thought to have receptors that filter the various stimuli we interact with in feature analysis. According to this theory, our nervous systems have receptors that filter the various stimuli that enter our brains. The receptors are known as feature detectors because they can encode the various features, or details, that make up an object.

Selfridge imagined the mind as a collection of tiny demons, each responding to the utterance of a name or a name-like phrase. When a demon feels called, it starts yelling to other demons. It yells louder and louder until another demon thinks it is being called and so on and thus Selfridge called it pandemonium model.

Perception and recognition of object, events or scenes takes through our sensory system such as visual, auditory, bodily or kinesthetic senses. Some theories claim to examine the role of separate sensory system working and some researchers claim the role of multiple sense modalities that work in coordination together.

An object cannot be recognized by the eye due to visual agnosia. It is not caused by early sensory vision, memory, or language abnormalities. Visual agnosia is a highly heterogeneous condition caused by injury to normal regions of the cortical visual system.

Perceiving others through their facial expressions, body language, and other nonverbal cues is the first step in social perception. One of the most important aspects of social cognition is face perception. When we reason about other people and try to understand what they are thinking, we use information transmitted from the face.

Face recognition is an important skill that develops early in life and contributes to our social abilities.

The human voice is a common and vital social element. Aside from being the primary carrier of language, voice has been shown to contain a wealth of socially relevant information such as sex of the speaker, emotions, age, intention, etc.

Motion perception is the process of inferring the speed and direction of objects in a scene from visual input.

2.4 QUESTIONS

1. What is Perception? Describe how recognition of objects, events and scenes takes place?
2. How does object recognition through visual system takes place?
3. How does object recognition through auditory system takes place?
4. Explain how object recognition through somatosensory perception occurs ?
5. What is Social Perception? Describe how we socially perceive faces.

6. Give the details of how social perception of voice takes place.
7. What is biological motion? and how it helps in social perception?
8. Write notes on:

   a. visual perceptual system

   b. somatoperceptive system

   c. social perception of faces

   d. social perception of voice

   e. biological motion

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3

ATTENTION AND CONSCIOUSNESS - I

Unit Structure

3.0. OBJECTIVES:

After studying the Unit, the learner will be able to understand:

- What is the nature of attention?
- What are the different types of attention?
- What are early theories of attention?
- What is the meaning of consciousness?

3.1. INTRODUCTION

Let us understand what is the meaning of attention in everyday life. One of the simplest example to understand attention is, driving a car. Imagine you are driving on one of the busiest streets in the city of Mumbai. There are numerous traffic signals, many vehicles trying to cut through the traffic, pedestrians trying to cross the road, several vehicles honking at the same time. Among all this you have to safely drive your car paying attention to lot of factors. So what processes are involved in driving a car? Obviously, certain physical skills such as controlling the steering, changing the gears, taking controls on the clutch and brakes etc., are needed and to a greater extent many cognitive processes are also required such as mental focus or concentration i.e., attention as referred by psychologists. Perception is another important cognitive process which is also involved, wherein one needs to quickly interpret the incoming information in form of all the stimuli from the environment (Crundall, Underwood, & Chapman, 2002).

In this chapter we are going to focus on how we are capable of carrying out this daunting task of paying attention to so many incoming stimuli from the environment, while ignoring others. How do we manage to shift our attention if all of a sudden, some pedestrian or vehicle suddenly appears in front of us while driving? And, Why we sometimes fail to notice certain objects occurring in front of our eyes?

3.1.1. Nature of Attention and its Types:

"Attention is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence" – William James (1890).

Let us now look at the nature of attention. Attention is one of the significant areas of investigation within the field of psychology, neuropsychology, cognitive neuroscience etc. 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; Rao, 2003). The topic of attention is important to us because there are several activities going on in the external world and simultaneously our mind is occupied by various thoughts in our internal world and we have to cope up and balance between them in order to effectively deal with our daily tasks. Attention includes both conscious and unconscious processes. We are very well aware about our conscious processes and they are easier to study but unconscious processes are harder to study as we are unaware of them. Attention is limited in terms of both capacity and duration; hence it is essential that we find effective ways to manage limited attentional resources available with us in order to make sense of the world around us.

Types of Attention:

Attention can be categorized into different types. Humankind uses these various types of attention depending on their need and circumstances, such as, i) If you need to focus your attention upon one task. ii) If you need to focus your attention upon more than one task at a time or multiple tasks at a time. iii) If you consciously need to focus upon few tasks and ignore other things going on at the same time. Hence depending upon the circumstances, you may employ any of the following types of attention.

1. **Sustained attention** - The ability to focus on one specific task for a continuous amount of time without being distracted. Example, Solving the maths problem

2. **Selective attention** – The ability to select from many stimuli and to focus on only the one that you want while filtering out other distractions. Example, listening to a person in noisy background.

3. **Divided attention-** The ability to process two or more responses or react to two or more different demands simultaneously. Example, cooking and talking on phone.

In order to understand the process of selective attention let us look at some of the early theories of attention.

3.2. EARLY THEORIES OF SELECTIVE ATTENTION

Selective attention basically refers to the fact that we usually focus our attention on one or a few tasks or events rather than on many. In a selective attention task people are instructed to respond selectively to certain kinds of information, while ignoring other information (Milliken et al. 1998). Perhaps you must have noticed that you can usually follow closely only one conversation at a noisy party whereas you cannot process the content of other conversation. Imagine if you had the capacity to participate in one conversation at the same time notice details of other conversations happening in the background. How will you deal with this situation? Wouldn't it be chaotic to process all the sensory information coming your way and making sense out of it and responding appropriately? Our attention is quite limited and it is almost impossible to attend to everything. The amazing ability of our brain to attend one information, filter out other irrelevant ones, and again shift the attention to a new stimulus helps us in focusing on the tasks at the hand amid the numerous stimuli in the environment. Fortunately, Selective attention has simplified our lives.

Dichotic listening task:

Fig:3.1. Source: John Jay Cognitive Psych on WordPress.com

The research on Selective attention is extensive. This has led to the proposition of many theories explaining the process of selective attention. **Cherry (1953)** conducted series of experiments on dichotic listening task depicting how we process simultaneous messages presented to different ears. The typical experiment consisted of two different messages being presented to different ears with the help of earphone. The participants were asked to shadow the message in one ear; i.e., they listen to the message and repeat it after the speaker whereas ignore the other message in the unattended ear. In this classic experiment people noticed very little about the unattended, second message. They even failed to notice that the unattended message changed from English to German. This ability to focus one's attention on a particular stimulus while filtering out a range of other stimuli (i.e., noise, other people's conversations etc) is referred to as **'The Cocktail Party Effect'**. Cherry observed that cocktail parties are often settings in which selective attention is salient. Wait a minute, Do you mean Cherry actually hanged out in numerous cocktail parties to study this phenomenon? I bet you are not serious. No Cherry did not actually hangout in cocktail parties to study this effect but rather he studied selective attention in a carefully controlled and precise laboratory settings. Though individuals were exceptional at this task of shadowing, but sometimes, however, they could notice the unattended message when the speaker's voice switched from male to female.

Also, when performing dichotic listening task, people sometimes notice their name being called out in unattended message (Moray (1959); Wood & Cowan (1995)). Imagine you are attending one party, the environment there is very noisy. You are having an interesting conversation with your friend. In the midst of the conversation, you hear your name being called out from someone at the other side of the room, you definitely would give it an ear to what others are talking about you. Hasn't this happened with you? We will discuss this point later.

Let's understand, why people were able to selectively attend to one conversation while ignoring other conversation in noisy background. To answer these questions further **Broadbent (1958)** proposed a **filter theory** of attention. Now let us look at the first formal theory of attention in the form of filter theory.

3.2.1. Filter Theory of Attention

The first complete theory of attention was developed by Broadbent (1958). This theory was called as **filter theory** of attention. Here Broadbent has used 'filter' as an analogy to explain the phenomenon of attention. This theory talks about the limits on how much information a person can attend to at any given time. Thus, if the amount of information available at given point of time exceeds the capacity, the person uses an attentional filter to let some information through and to block the rest. The filter is designed to prevent overloading by selecting the relevant information to process. Since this theory focuses on our limited capacity to pay attention, they are also called as "Bottleneck" theories.

Broadbent's theory predicts that hearing your name when you are not paying attention should be impossible because unattended messages are filtered out before you process the meaning, thereby rejecting the cocktail party effect. Let's have a look at Broadbent's bottleneck model, how the capacity for paying attention has been conceptualized as a bottleneck, which restricts the flow of information. The more the narrower the bottleneck, the lower the rate of flow.

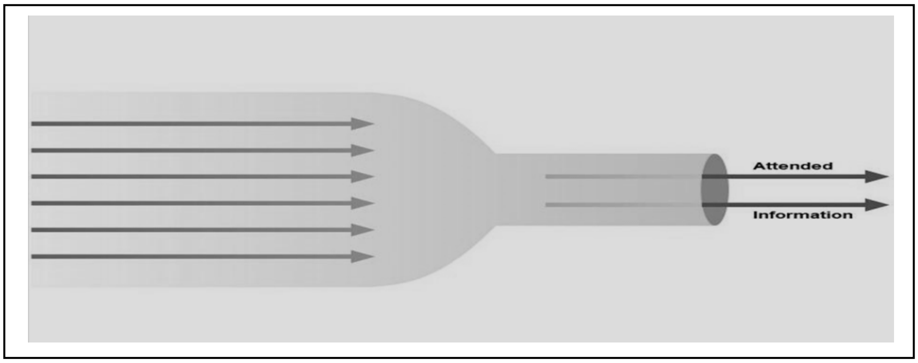


Fig. 3.2. Imagine this bottleneck, the arrows that you see entering from the base of the bottle are various stimuli that are trying to enter through your sense organs. Further let's say you are waiting at the bus stop for your bus. Now there are six arrows, so assume six different stimuli are bombarding through your sense organs.

→ Stimulus one- (song played in background at the nearby food stall)

→ Stimulus two- (random conversation between two friends)

→ Stimulus three- (girl with red coloured dress)

→ Stimulus four- (various buses passing through the bus stop)

→ Stimulus five- (sounds of horn from various vehicles)

→ Stimulus six- (several pedestrians walking down the road)

Out of these six stimuli, there are two stimuli that have entered through this bottle neck which get attended i.e., stimulus 3 and stimulus 4. This means rest of the stimuli are filtered out. According to Broadbent, all stimuli are processed initially for their physical characteristics, such as color, pitch, loudness, intensity etc. Based on these physical characteristics, some of the stimuli pass through the filter for further meaningful analysis. Filter theory reflects an early selection theory because certain information is selected and attended at early stage of information processing.

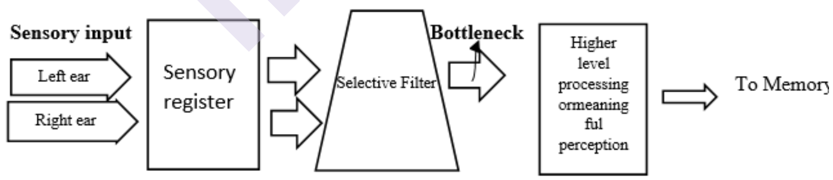
But as one can see, that people were still able to hear their names being called out from unattended ear. How was this possible? and this was a serious challenge to Broadbent's model. After Cherry demonstrated the Cocktail Party effect, Moray and Wood and Cowan extended their work further on this effect. Moray found that people could detect their names from unattended ear, but however not everybody demonstrated this effect only about 33% of subjects reported hearing their own names in unattended ear. Wood and Cowan replicated Moray's experiment and found that 34.6% subjects repeated their names. They also used different experimental setup wherein they presented the participants with two different speeches in separate ears and asked the participants to shadow one of the messages presented, after 5 minutes backward speech was introduced for about 30 seconds. Wood and Cowan wanted to know those who noticed backward speech whether they showed disruptions in their shadowing task. They found that shadowing errors peaked to the highest among those who noticed the backward speech. Wood and Cowan believed that this backward noticing of speech occurred with the participants as the backward speech “captured” their attention and this led to poorer performance on main shadowing task. Later Conway, Cowan and Bunting (2001) discovered that people who had lower working memory span showed more shadowing errors as they had difficulty blocking out, or inhibiting, distracting information from unattended channel. Working memory allows us to hold important information in our mind for a temporary period of time and allows us to process various cognitive tasks.

3.2.2 Attenuation Theory

Anne Triesman (1960) proposed the ‘**Attenuation Theory’** which is a modified version of Broadbent’s filter theory. According to Treisman, unattended messages are not completely blocked out of filter but rather their “volume” was “turned down” or attenuated. An attenuator is an electrical equipment that controls or reduces the power of electrical signal or wavelength without distorting it. Triesman used this as an analogy to explain her model. In simple words, what did Broadbent propose, that unattended messages are completely blocked before they could be analyzed in terms of meaning, whereas Treisman proposed that unattended messages are attenuated, in the sense processed at a weaker level but not entirely blocked from further meaningful processing. As a result, highly meaningful and relevant information in the unattended ear will get through the filter for further meaningful processing.

Let us have a look at the diagrammatic representation of the original filter model and Attenuation model for our understanding.

Broadbent’s Filter Model



Treisman’s Attenuation Model

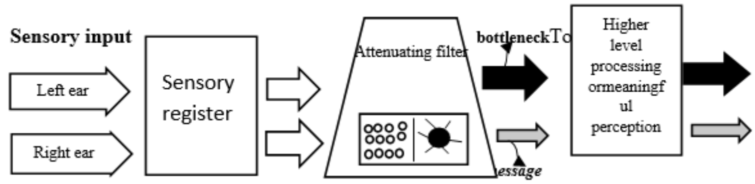


Figure 3.3 Comparative analysis of filter model and attenuation model in a typical dichotic listening task.

In the above diagram; fig.2.2.2. have a look at Broadbent's model, one can see how sensory input is entering the sensory register i.e., your sense organs, from thereon the information enters a selective filter which is processed further for meaningful analysis. In attenuation model, all incoming sensory input enters the sensory register, which later passes on through attenuation filter, where based on their physical properties such as loudness, pitch, intensity, threshold value of stimulus, etc, further meaningful analysis is done. The only difference here is, that, the attended messages pass through the attenuator at full strength whereas unattended messages pass through with reduced strength.

According to Treisman, people do required processing as per their needs to the level that they can separate attended from unattended message. People first compare the two messages.If the messages are differing in terms of physical property, they will only process upto this level and easily reject the unattended message. If they realize messages differ by semantic properties, they only analyze upto semantic level. However, semantic processing is much time consuming and people do it only when necessary.

Filter theory allows only single kind of processing whereas attenuation theory allows for different kinds of processing. Filter theory discards blocked messages whereas attenuation theory holds the unattended messages and assumes their availability in weakened form.

3.2.3. Late Selection theory

The above two theories described, fall into early selection theory. Early selection theories propose that sensory inputs are selected for attending or processing on basis of their physical properties even prior to stimulus identification, hence unattended messages are not fully processed. In Late selection theories, stimuli or sensory inputs are attended only after meaningful analysis of it. A Late Selection Theory of Attention was proposed by Deutsch and Deutsch (1963). According to them, both attended as well as unattended sensory inputs are analyzed in terms of meaning and then identification of stimulus takes place. The later selection or filtering allows the people to recognize incoming information in unattended ear and then depending upon the pertinence, relevance or importance of the incoming stimulus or information it is selected for attending and further detailed processing. Both early selection and late selection theories emphasize on attentional bottleneck through which only a single source of information can pass at a time. The only difference is where they hypothesize the bottleneck to be positioned.

3.2.4. Multimode Theory

The Multimode Theory was proposed by Johnston and Heinz (1978). The previously given theories such as early selection theory was not able to explain why some of the messages get noticed from the unattended ear. Whereas on the other hand, late selection theories didn't quite explain how so many messages are simultaneously processed for meaning. So, a theory that could explain this aspect of attention was needed. This theory proposes that attention is flexible and allows selection of one message over another at various different points during information processing. The processing of information or selection of perceptual messages can occur at any of the three stages depending on the need of the observer.

Stage-1- During this stage stimuli is represented in terms of sensory properties.

Stage-2- During this stage stimuli is represented in terms of semantic properties.

Stage-3- During this stage both sensory and semantic representation come into conscious awareness.

As per this model selective attention process can occur either at an early stage, when stimulus is analyzed in terms of physical properties, thus, requiring less capacity or effort on part of the individual. On the other hand, if selective attention occurs at later stage wherein meaningful or semantic analysis of stimulus is done, it requires more efforts, thus, later the selection harder the task on part of individual.

Johnston and Heinz (1978) conducted experiments to show how late selection affects the individual's performance negatively. The participants were given two simultaneous tasks to perform. It was a standard dichotic listening task. The participants had to shadow one message where the messages physically differed in terms of different speakers of different sex which facilitated early selection. At other times, the messages differed in terms of meaning thus requiring late selection. At the same time second simultaneous task had to be carried out by the participants where they had to detect a light presented to them by pressing a key as soon as possible. Results showed that when the messages had to be selected on basis of sex of speaker it was early selection, and required lesser effort on part of individual and they were responding with speed to the light signal. Whereas processing difficulty increased as the participants had to analyse the stimuli on basis of meaning requiring more efforts to shadowing task, thus delaying the response time. One of the major findings which was discovered later by these researchers was that processing does not require more mental resources or efforts but rather selecting the message requires more resources.

3.2.5. Kahneman's Model of Attention and Effort or Resource Theory

Daniel Kahneman (1973) proposed a new model of attention which is referred as Kahneman's model of attention and effort or Central Resource Capacity Theory or Resource Theory. This theory drops the filter notion and regards attention as limited resource or limited capacity which needs to be distributed or allocated appropriately to various tasks. How people allocate different attention resources primarily depends on these factors (1) enduring dispositions (preferences, novelty of stimulus, automatic influences on attention etc), (2) momentary intentions (your priorities, goals at the moment, conscious decision to attend to few stimuli etc, e.g., first I need to search my id card before anything else), (3) Evaluation of demands on capacity (awareness or knowledge regarding a task that would require more attention or less attention). And availability of those resources in turn depends upon overall level of arousal.

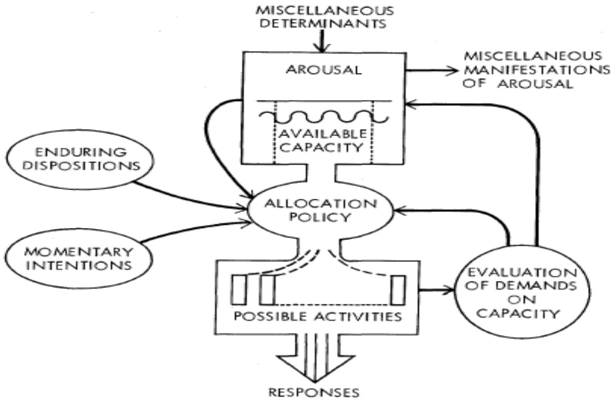


Fig 2.2.5. Source: images by Creative Commons.

Research on selective attention and an idea of an attention as a resource gave an opportunity to draw many new metaphors related to attention. One such metaphor was the **'Spotlight Metaphor'**, where attention was compared to a Spotlight. Now we all know what is a spotlight. It is an intense beam of light which is directed at one particular part of stage or on a main performing character on stage. This intense beam of light highlights or illuminates the particular area where it is thrown, which becomes distinctly visible to us whereas rest of the boundaries become fuzzy. Again, when the spotlight moves from one place to other on stage newer areas become focal point of attention and the other area becomes fuzzy. Similarly, take an instance of attention. As the focal point of spotlight can be moved from one area of stage to other, attention can also be directed and redirected to various incoming information. Just as spotlight enhances the area where its thrown similarly cognitive processing is also enhanced when more attention is paid to it. Also, how large a spotlight is and whether the size of the spotlight can be changed was a concern and to answer this Eriksen and Yeh, 1985, proposed **'Zoom lens model'**. Just as we can cover an area with our camera by 'zooming in' and 'zooming out' same way we can widen or narrow down our attention at specific locations. The cognitive operation of 'zooming in' process reduces the spatial scope of attention thereby leading to faster responses and fewer errors as smaller the area more attention could be paid and processing efficiency improved. And the 'zooming out' process enlarges the spatial scope of attention leading to slower response and more errors as the larger the area less attention being paid to all the details thus reducing efficiency (Qi Chen et al.,2009). Both spotlight and zoom lens metaphor only focused on attention as a resource that spread across a specific visual area without taking into consideration the objects that inhabit that space.

Attention can be characterized as being applied to objects rather than merely spatial location that the object occupies, as demonstrated by Egly, Driver and Rafal (1994). These researchers showed that attention can be bound to objects. They asked the participants to fixate their attention on one particular object on the screen after which they were cued the spatial location of that object where a target will appear, for example, at the top border of the object (In the experiment rectangular bar was the object and location of target was indicated by brightening the end of the location as cue where the target will appear). The target either appeared at the cued location or either at an uncued location. The participants were asked to detect the onset of the target and the results indicated that when the target appeared on cued location it was detected faster than when it appeared on uncued location. Though there was a delay in time to detect but however enhanced processing of the entire triangle as indicated by results supports the Object-based attention.

3.3. AUTOMATICITY OF ATTENTION AND EFFECT OF PRACTICE:

What is automaticity? Take a simple example, like typing. If you are a naive typist, you will realize that your typing speed is very low and probably you are able to type only few words a minute. But as you keep on practicing you get better at the task and more and more skilled you becomes able to allocate your other mental resources to talking with other people or singing along side typing, responding to casual conversations etc. In simple words, you can process incoming information at the same time carry out your typing work without much errors.

Practice is thought to reduce the amount of mental effort required for any task and you are able to allocate more resources to other incoming information. Automaticity thus refers to the ability to effortlessly complete everyday tasks with low interference of other simultaneous activities and without conscious thought to step-by-step process.

a. The Stroop Effect:

One of the popular experiments conducted by John Ridley Stroop (1935) demonstrates the phenomenon of automaticity and effect of practice through 'The Stroop Effect' experiment. In this experiment participants were presented with series of color names printed on a sheet and their task was to name the ink colour of the printed word rather than reading what the word is. There were two conditions, one was the congruent color word condition and the other one was incongruent color word condition. In the congruent condition the name of the color and the ink in which color was written was same (for e.g.; the word "pink" printed in pink colour, color name "brown" printed in brown colour, etc). Whereas in the incongruent condition the name of the color and the ink in which it was printed differed from each other (for e.g., the color word red printed in black color; the color word green printed in purple color, etc.). The congruent condition was faster as there was no interference since the color name and printed ink matched with each other but in the incongruent color word condition there was delay in naming the ink color as the participants had to inhibit themselves from reading the color word. If they were shown the word red written in black colored letters they had to name the ink color i.e. black. Every time while performing this task participants experienced interference due to in congruency.

Why this kind of delay occurs in incongruent tasks? The reason being the very human nature. As an adult literate participant, we are so used to reading verbal material due to much practice in reading, reading becomes almost automatic requiring little attention and is performed rapidly. So according to Stroop, not reading words is really hard, hence in the incongruent color word condition, the reading of the word occurs automatically but since it has to be inhibited and color name has to be produced the response time gets delayed. This kind of response mechanism occurs due to automaticity. The same Stroop task was modified in various ways and different experimental conditions were studied further.

(b) Automatic v/s Controlled Processing:

Automatic vs controlled processes of attention are another important aspect of attention. Controlled processes are the one which are also referred as attentional processes. Posner and Snyder (1975) have given three criteria for automatic processing;

Automatic Processing:

(1) It should occur without intention.

(2) It should not involve conscious awareness.

(3) It should not interfere with other mental activity.

The automatic processes can be used with tasks that are easy. Their processing is parallel, means we can simultaneously carry out two or more tasks at the same time. Examples of automatic processing are, walking back home from office, singing your favourite song etc.

Controlled processing requires us to pay attention. Controlled processing tasks are carried out intentionally and deliberately. We are consciously aware about them. We have to think and be aware about what is happening. We are in total 'control' of these processes. Controlled processing is serial, means we can handle only one task or activity at a time. Examples of controlled processing are, solving a complex arithmetic problem, driving car for the first time etc.

Some of the controlled tasks can be made automatic with practice. Like in case of Stroop effect experiment when the incongruent color word condition task was given to participants for practice, it showed improved performance and response speed increased.

Classic study on difference between automatic processing and controlled processing was carried out by Schneider and Shiffrin in 1977. The participants were presented with various frames containing numbers and letters printed upon it. The participants had to search for target among the array of letters or numbers or both. Sometimes the target was number which was presented in frame along with letters, making the task easier, thus allowing automatic processing, where the processing was parallel. In the other condition, the complexity of task increased as the targets were mixed along with distractors that were also of same nature i.e., searching a target number from different arrays of numbers or letters presented as target alongside other letters. Sometimes in same frame, along with target same target in a different color was kept as distracter. Here the task was complex and participants were required to pay more attention and use controlled processing. Schneider and Shiffrin observed that participants were making use of serial processing by paying attention to individual item one at a time.

(c) Feature Integration Theory:

This is another approach related to attention. Since many of the factors related to attention also involves many aspects of perception and recognition, Anne Treisman(1980) developed **Feature integration theory.** Treisman has explained different ways by which features of the objects are distinguished. First is recognition of individual features of objects in terms of its shape and color. Second, the individual features are then combined together into unified whole. Let's take an example. When individuals are presented with blue square, what do they observe? They see the color blue then notice the shape of the object, that it has 4 equal sides, recognizing it is a shape of square. Similarly, letter X consists of two slanted lines one towards right and the other one towards left. According to Feature Integration Theory, each of these features are processed separately. Then in the next step you combine all the features and come up with the response recognition. The more the combination of features, slower will be the response in visual search tasks (like searching for red letter M among different coloured letters). If a single feature needs to be searched for, then faster will be the detection and processing is parallel as all objects are inspected simultaneously. When more combination of the features is presented, serial processing is required as each objects needs to be inspected one at a time and people sometimes make **illusory conjunctions** (Treisman and Schmidt, 1982). Illusory conjunctions happen when you erroneously combine features of different objects together (like if you see a man wearing green shirt and cream pant and there is another person with pink shirt and blue pant, you end up erroneously combining features of them by identifying that I handed over the papers to man with blue shirt and green pant).

(d) Attentional Capture:

During visual search tasks when some of the stimuli 'pop out' or demand attention, where attention is involuntarily caught by the stimulus, this phenomenon is called as attentional capture. Here the stimuli automatically invites the perceiver's attention. In attentional capture there is involuntary focus of attention occured by change in stimulus or sudden appearance of new stimulus which interrupts or diminishes the processing of other events, tasks or information. An important study was carried out by Theeuwes et al (1998) to study attentional capture. They tried to find out if irrelevant stimuli which would appear suddenly could control the participants attention and distract them from the task at hand of identifying certain stimuli on the screen. It was found that when there was sudden appearance of this distractor stimuli and participants were not warned about it , it affected their performance negatively whereas when the participants were warned about only looking at specific location, they did not have their attention captured by the sudden appearance of new stimulus.

3.4. SUMMARY

Summing up, the process of attention was understood through many approaches given forward to us by different psychologists. We will further delve into the remaining topics of attention in the next unit, where we will discuss upon how sometimes failure to attention occurs. We shall also discuss about the divided attention and most importantly the process of consciousness.

At the beginning of the unit, we saw attention is limited in terms of both capacity and duration; hence it is essential that we find effective ways to manage limited attentional resources available with us in order to make sense of the world around us.

Attention can be categorized into various types; sustained attention, selective attention and divided attention. The ability to select from many stimuli and to focus on only the one that you want while filtering out other distractions is *Selective Attention*. Example, listening to a person in noisy background. There is immense literature available on selective attention and wealth of data is also available in the form of various theoretical constructs given by different psychologists. They have made us realize that attention is flexible process which is impacted by various factors such as arousal, capacity, momentary intentions, practice etc.

The earlier theories of attention focused on early filter and late filter. Attention process was compared to a bottleneck. According to Broadbent's early filter model none of the unattended messages would be available to the individual to be processed further meaningfully. But with findings of cocktail party effect Broadbent's model was rejected as one could perceive their name or sensitive or highly pertinent information from unattended ear.

Inspired by Broadbent many researchers alternatively came up with many new theories to explain the attention process. Treisman came up with attenuation model as according to her all sensory inputs are perceived by the perceiver but only the relevant one is selected which is available in full strength and other stimuli are attenuated or their volume is turned down in the sense they are weakly available.

The late selection theories gave the notion of filter at later stage meaning all stimuli that enter through your sense organs are analyzed for meaning and then their selection happens to attend them.

Later many metaphors were compared to attention such as spotlight metaphor and zoom lens metaphor. Both spotlight and zoom lens metaphor only focused on attention as a resource that spread across a specific visual area without taking into consideration the objects that inhabit that space.

It was also discovered that practice with certain cognitive tasks can make those same tasks automatic in nature. Practice is thought to reduce the amount of mental effort required for any task and you are able to allocate more resources to other incoming information.

Automatic vs controlled processes of attention are another important aspect of attention. The automatic processes can be used with tasks that are easy. Their processing is parallel, which means we can simultaneously carry out two or more tasks at the same time. Controlled processing requires us to pay attention. Controlled processing is serial, meaning we can handle only one task or activity at a time.

Anne Treisman developed Feature integration theoryand explained different ways by which features of the objects are distinguished.

During visual search tasks when some of the stimuli 'pop out' or demand attention, where attention is involuntarily caught by the stimulus, this phenomenon is called as attentional capture.

3.5. QUESTIONS

1. What is attention and discuss its nature and its type?
2. Describe the dichotic listening task and explain how psychologists use it for their experimentation?
3. Describe filter theory of attention?
4. Give in detail various selective attention theories.
5. Describe in detail Resource capacity theory of Kahneman?
6. What is automaticity and effect of practice?
7. Write notes on :

   a. feature integration theory.

   b. attentional capture

   c. stroop effect

   d. Automatic v/s controlled process of attention.

3.6 REFERENCES

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4

ATTENTION AND CONSCIOUSNESS - II

Unit Structure

4.0 OBJECTIVES:

After studying the Unit, the learner will be able to understand:

- Why sometimes we fail to notice certain stimuli?
- What are errors in attention and how do they affect us?
- What is divided attention?
- What is consciousness and its function?

In the earlier unit of attention, we discovered many selective attention theories at the same time how automatic and controlled processes of attention affect various tasks. In this chapter we are going to cover one of the important aspects of attentional failure. What happens when we fail to notice certain stimuli? Why this error in attention occurs and how it might affect us? We shall also focus on another important type of attention i.e., divided attention. We will try and answer is division of attention possible? What exactly is happening when you are dividing your attention to two simultaneous tasks?

4.1 ATTENTION FAILURE

We had observed in the earlier unit in the concept of attentional capture, where sudden appearance of the stimulus attracts attention of the viewer. But at times we have also noticed that even when certain stimuli are there in front of us, we still miss them. Take an example of driving. Often times accidents occur when all of a sudden certain vehicles or people come in front of you but you fail to notice them. There could be several reasons why this temporary shift in attention takes place and person gets distracted due to certain factors both within and outside of them. We can call them as internal and external determinants. The internal determinants could be mind wandering, absent-mindedness, emotional state etc. Among the external factors, movement, intensity, size of stimulus, etc can cause disruptions in attention. Psychologists have studied two major aspects of failure to attention in the form of;

(1) Change Blindness and, (2) Inattentional Blindness.

4.1.1 Change Blindness:

Change blindness is the phenomenon where substantial differences between two nearly identical scenes are not noticed when presented sequentially. This phenomenon was demonstrated by Rensink in 2002. We have a general tendency to remember or understand events or scenes in gist or summarized form but we experience difficulty when we are asked to report the scene or event in detail. In change blindness the observer fails to notice change in the stimulus when it undergoes changes. Such types of instances could be mostly observed when we are watching movies and are unable to detect editing errors. You are actively watching a scene and are completely engrossed into it that you miss upon the errors and later when someone points out you realize, Oops! How is that possible? One of the famous editing error could be noticed in the the popular movie 'Sholay' where the character 'Thakur' (whose both hands were amputed from shoulder) when fights with' Gabbar', it could be easily seen that his hidden hands were dangling out from his shirt, but people were so engrossed in this scene that many failed to notice it. Many Psychologists concerned with change blindness issue related to attention have carefully studied this phenomenon through laboratory experiments as well as real world settings. In one such real -world experiment, more than half of the participants failed to notice the changing of a conversation partner in front of them (Simons and Levin, 1998; Levin et al., 2002).

4.1.2 Inattentional Blindness:

Inattentional blindness is the failure to notice a clearly visible target due to attention being diverted from the target. The difference between change blindness and inattentional blindness is that in change blindness you are unable to notice a stimulus that has undergone changes whereas in inattentional blindness the target is present right in front of you, but still you are unable to notice its presence as you are engrossed or distracted with some other task. It generally happens because subjects are not attending that stimulus but instead are attending something else. The term "Inattentional blindness" was coined by Mack and Rock (1998). One of the famous experiments depicting the inattentional blindness is the 'invisible gorilla' experiment (Chabris and Simons,1999). The participants in this experiment were asked to watch a video of basketball game and count the number of times a ball passes. Later after the video the participants were asked if did they noticed anything unusual in video. Half of the participants did not find anything unusual, but in fact there was a lady dressed as gorilla who strolled in between the players, came in front of the camera. Still participants were not able to notice her; hence the experiment became famous as invisible gorilla. Why did this happen? One reason was that participants were already engrossed incounting the ball passing and were tracking their eyes all over the players passing the ball, which made them fail to notice the gorilla. Inattentional blindness is a part of selective attention process as you are actively engaged in one task and therefore unable to notice another fully visible stimulus right in front of you. Many a times based on top-down process we try to the fill gap of the scene through our schematic representation. The availability of schemas prevent us from expecting an unusual stimulus in the scene, as this could be the possibility in invisible gorilla case.

4.1.3 Attention Deficit Hyperactivity Disorder (Adhd):

People who suffer from ADHD experience difficulty in giving focused attention to any task. The DSM-5™ (Diagnostic and Statistical Manual of Mental Disorders) defines ADHD as "A persistent pattern of inattention and /or hyperactivity- impulsivity that interferes with functioning or development". As one can see the definition itself mentions, inattention, hyperactivity impulsivity as the major criteria for diagnosis of the above disorder. Since one of the criteria of ADHD is inattention, this is of much relevance to our discussion on attention failure. Children who suffer from ADHD often experience difficulty in maintaining attention during the class when the teacher is teaching. They get easily distracted by irrelevant stimuli in the environment. They cannot complete their work on time due to lack of attention etc. There are various probable reasons associated with this disorder like toxins, chemical changes in the brain, food additives etc. With the use of medications, psychological treatment and educational intervention programs, this condition can be brought under control to an extent.

4.1.4 Neuropsychological Conditions -Hemineglect:

There have been important studies in the field of neuropsychology where cognitive neuropsychologists are interested in examining different areas of the brain and how these areas are responsible for the function of attention process. Their pioneering studies have brought forward evidence based results from patients suffering from parietal lobe damage who suffer from a condition called hemineglect. In this condition the patient who suffer from right parietal lobe damage often neglect information falling in the left visual field. In order to study if damage to that area might affect attention function, they were made to copy few simple drawings that were presented to them. These drawings were of simple objects like clock, jug, house etc. It was found that these patients were able to copy only one side of the drawing. Some of the sample drawings can be seen below.

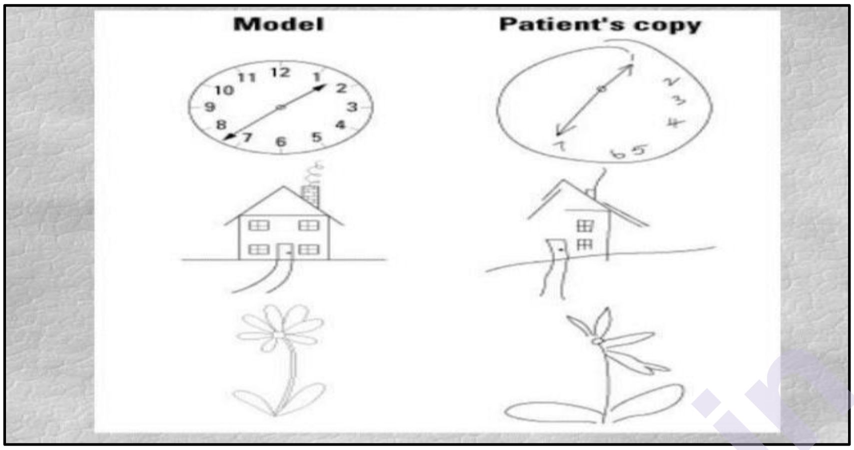

Fig. 4.1.Drawing of a Patient with right hemispheric damage. As can be seen the patient with right hemisphere damage due to stroke has completely ignored the left side portion of the drawing.

With the above studies it was discovered that both areas of the parietal lobe and frontal lobe are associated with attention.

4.2 DIVIDED ATTENTION

The topic of divided attention is of utmost importance as we know attention being a limited resource, we are concerned with how this limited resource can be allocated for doing two or more than two mental tasks simultaneously. We are required to pay attention to both the tasks or all the tasks at the same time. Since we have limited capacity to attend and respond to multiple stimuli, when the attention is divided among different tasks, the efficiency of the performance decreases. You tend to perform poorly at those tasks. But is division of attention actually taking place or something else is happening? Can one divide equal attention to two mental tasks at the same time? Spelke, Hirst and Neisser (1976) were the earliest researcher to work on divided attention. Through their dual task studies they found that participants performed equally well on meaningful interpretation of dictation task along with reading task and there was no compromise on speed. This made some Psychologists to conclude that participants were shifting their attention alternately from one task to the other. Many assumptions were put forward regarding theory of divided attention and it was believed that, first, division of attention was possible only under certain circumstances like when out of the two tasks one of the task is automatic and mechanical in nature and the other one is mental (e.g., Eating popcorn and writing your homework) then majority of the attention could be given to completion of the mental task. Second, people make quick shifts in attention by alternating their attention, to and fro from one task to the other. But soon however Hirst, Spelke, Reeves et al (1980) found evidence against the possibility that one task becomes automatic or automatized. Here again the role of practice was emphasized for making division of attention with two mental tasks possible.

Some of the tasks that demand divided attention can be found in certain fields or professions like drivers, pilots, telephone operators, people working on machine with multiple level functions to control working of the particular machine, etc. As a driver he needs to pay attention to the incoming stimuli coming in front of him such as other vehicles, pedestrians, signals, sudden overtaking by another vehicle from behind, controlling the clutch, accelerator, brakes, speed braker on the road etc. He needs to be very vigilant in attending to various environmental cues. Imagine even if one of the cues is missed by the driver, it would turn into a major mishap. So, we need to analyse regarding how to improve our divided attention. You either need to be a super computer with exceptional abilities to perform this task flawlessly. Or we need to improvise upon our cognitive skills by training our brains in doing so. This is where the current research on neuroplasticity is gaining impetus in the field of psychology, neuropsychology and the like.

4.2.1 The Attention Hypothesis Of Automatization:

The above hypothesis was proposed by Logan and Etherton (1994). According to this hypothesis, attention is needed during a learning or practice phase of new task and also takes into consideration what will get learned during the practice phase, and at the same time, what will be remembered because of practice. In simple terms if you are paying attention to how to operate an EVM box (Electronic Voting Machine), you will learn its operation stepwise, regarding how to setup and operate the machine, but if you never paid attention, you will not learn much about how to operate the machine.

Logan and Etherton carried out experiments to answer the above assumption that if we do not pay attention during the learning phase then learning will not take place. Their study is concerned with what is learned during automatization. They presented participants with two-word display (for e.g., Steel and Canada) and asked them to detect the target word containing the name of metal. To some subjects the condition was divided attention condition in which they would focus on both words that co-occurred together. For one group of subjects the metal word would be consistently paired with same word(always the pair "Steel and Canada") and for other half of the subjects, the same metal word was paired with other words ("Steel and Broccoli", for example). To yet another group they merely showed a cooccurred word printed in colour and had to name that color. Later the participants were only shown the co-occurred word and they had to respond if this word contained the target. If the automatization hypothesis is true then participants in the colour word condition will not pay much attention to the coloured word as they only paid attention to colour thus making them ignore the meaning of second word and thus apparently little gets learned.

4.3 CONSCIOUSNESS

Attention and consciousness share a close relation with each other in the domains of cognitive psychology. Attention is focusing of consciousness on a particular stimulus, object or task. While utilizing attentional resources we are able to process only limited amount of information from the humongous information available through our senses, memory stores etc. Consciousness basically means being aware of both external events as well as internal feelings and sensations felt from within. For example, you could be consciously aware of all the external events happening around you like, different people, the clothes they are wearing, you might also overhear various conversations between them, all the environmental cues such as trees, buildings, vehicles, drum sound from nearby school children practicing for parade, your own actions of either walking down the road, or sipping tea at the tea stall etc. At the same time while sipping tea numerous thoughts are running in your mind regarding the incomplete presentation that is pending, or probably sudden thought of unpaid electricity bill making you more nervous and anticipate the thought of spending night in dark as the connection might be disconnected. In short, along with fleeting thoughts you are also aware about various feelings of anxiety, nervousness etc. Thus, you are consciously aware of what is happening with you internally.

Now these are the things which you are very well aware of and you have full meaningful interpretation of what is happening around you as well as what is happening within you. But at times there are certain stimuli or events which occur around you that you register but you are not consciously aware about them. This phenomenon is studied under the topic of **subliminal perception.** The research work on subliminal perception dates back to the year 1898, when researcher Sidis published his work in the book, 'The Psychology of Suggestion', New York, 1898. The book describes series of experiments done on sub-waking self. According to him, there is existence of sub-waking self within us that perceives things which the primary waking self is unable to get at . In subliminal perception we can register or react to a stimulus but we are unable to perceive it consciously. Subliminal advertising had gained lot of popularity when a marketing researcher, James Vicary (1957) had claimed that there was sudden increase in the sales of Pop Corn and Coca-Cola in the theaters. He claimed that he flashed the words, 'Eat Popcorn & Drink Coca-Cola' for about .03 seconds to the movie goers in theatre, which led to the sudden increase in sales of popcorn by 57.5% and Coca- cola by 18.1%. This became important topic of discussion among researchers and Psychologists to recognize the power of subliminal perception. But later, this entire experiment turned out to be a mere facade and Vicary committed to the fraud done by him. As researchers began replicating this experiment, the idea of subliminal perception in advertising field, in terms of increasing sales, was not working.

The research on subliminal perception has a long history in Psychology (Pierce & Jastrow, 1884). It has been argued that the modular and distributed nature of cognitive structures promotes the possibility that we would internally possess information to which we have no awareness (Erdelyi, 1974).

Coming back to consciousness, there has been lot of debate regarding considering consciousness into scientific realm. Since the scientific approach is based on objectivity and facts and the very current definition of consciousness emphasizes subjective or one's own experiences, the scientist's face dilemma. Often, to study consciousness or understand what this conscious experience includes, Philosopher Frank Jackson (1982) introduced one technique known as 'Mary's room' (knowledge argument) to unravel the mystery of how all that is mental in the universe cannot always have physicality associated to it, but much more knowledge is attainable and discoverable through conscious experiences. In Mary's room knowledge argument, Mary is thought to be a brilliant scientist and color expert who has immense knowledge about the structure and functioning of the eye, exact wavelengths of light stimulating retina, at the same time she is also expert in colour theory. But Mary was somehow forced to live in a room with black and white books, and monochromatic background, though she had never had any first-hand experience with colors but still she perfectly knew everything about the different colors that one could have learned. For e.g., the color red was never physically seen by her, what she knew was only from a third person perspective. So, one day when Mary had a chance of breaking out of the room and move along the monochromatic corridor, she discovers a red color door. Now this is her first person encounter with color red. How will Mary relate this experience? Will there be a difference in her experience of color red from her earlier view while in monochromatic room to now? So, with the story of Mary's room Jackson wanted to argue the experiences Mary had, and the differences between both. Will Mary gain new knowledge from the actual experience of the colour red? The earlier monochromatic experience was completely mental without any physical component to it and the later experience was encountering it in physicality. So, the information on the color red remains the same but her sensory experience of color red and its *qualia* (experiential properties of sensations, feelings, perception) are newly acquired with this new experience. There were many arguments and different philosophers have put forward their views from this knowledge argument but no tenable outcome was satisfactorily accepted and the debate still continues.

4.3.1 Function Of Consciousness:

(a) Conscious inessentialism and Epiphenomenalism

Humans possess this amazing ability of consciousness which helps them to understand and introspect themselves, assess their feelings, control their behaviour and process higher order information. These abilities make them unique and easily distinguishable from animals. Many researchers argue that we have a very little direct access to our thought processes. You may be fully aware of certain products of thought processes, like the name of your first pre-primary school, or your favourite meal that you had when you went for some trip, but you may not be aware or conscious about how this cognitive process was created. So let us explore what are the various functions of consciousness.

With respect to the function of distinctiveness, there have been two distinctive views regarding consciousness. One is conscious inessentialism and the other one is epiphenomenalism. As per conscious inessentialism view, consciousness is not necessary for carrying out intelligent activity, let’s say, like, writing a research article, listening to an important neurology lecture, or maybe, just buying grocery items etc. This does not mean there is complete denial of conscious accompaniment in intelligent activities, but rather it is a contingent fact (existing only if are the case) not a necessary one (Flangan, 1992). The *zombie* argument is often used for philosophical discussion of conscious inessentialism. The existence of zombie is seen to be contingent issue which depends upon how well you conceive the existence of zombie.

The second view regarding the function of consciousness is epiphenomenalism view. This view states that consciousness has no function. Epiphenomenalism is the view that mental events are caused by physical events in the brain, but have no effects upon any physical events (Huxley, 1874). Huxley compared the mental events to a steam whistle that has no role to play in movement of locomotive engine.

(b) Volition

Volition is anything done voluntarily. Volition refers to an individual’s ability to select various cognitive processes and decide upon course of action. In other words, it refers to individual’s free will. Whenever individuals have to decide anything with free will or volition they need to rely on conscious effort (Hakwan Lau, 2004). Volitional processes can also be automatized by developing habit over time. For example, there are many complex decisions that individuals take, which are planned, like going on a trip, pursuing education in particular field, prioritizing many goals in life etc. Benjamin Liget and his colleagues conducted one experiment on ‘free will’ in 1983. According to him, decisions are made by the brain at free will, unconsciously, before being realized into consciousness.

As per the new research, the part of the brain that controls free will is parietal cortex. There are specific regions in brain (Parietal cortex and premotor cortex) that are involved in the consciousness of movements (Angela Sirigu, 2004).

(c) Global workspace theory:

Global workspace theory (GWT) proposes that consciousness requires interaction across a broad range of brain areas. This theory was proposed by Bernard Baars (1988, 1997, 2002). GWT is thought to be similar to the concept of working memory, especially the way executive function is performed by the working memory. Baars proposed that in the consciousness system, a structure called “Global

Workspace", is accessible by consciousness out of the whole cognitive system. Global workspace facilitates integrative function across extensive brain network, where it creates the summary of the network. It largely provides us information about our own feelings of pain, pleasure etc at the same time helps us to take insight of our actions, of other people's actions and alike. GWT is also compared to 'theatre metaphor'

Some of the other functions provided by consciousness are learning, skill acquisition, rational thought and detecting error (Gilhooly et al,2014). Consciousness can also be related to the medical and law field especially when considering the case of sleepwalking. The question, can one be conscious while sleepwalking? What does our legal system say, if any crime committed during attack of parasomnia? The much interesting case of one such intersection between medical and law field came into popularity when one Canadian man, Ontario during one such attack, happened to travel a long distance and enter his wife's parent's house and killed both her parents, later he surrendered himself to nearest police station in a confused state. He was finally acquitted from both murder and assault. He could not be deemed as a culprit legally as it was considered as this incident happened without his conscious awareness and that sleepwalking is sleep disorder and not mental illness (Glancy, et al, 2002).

4.4 RELATIONSHIP BETWEEN ATTENTION AND CONSCIOUSNESS

Attention and consciousness seem to be so entangled with each other, that one cannot think of consciousness and attention being studied independently (Jeroen, et al). Though clearly it is indicated that attention and consciousness both help in further cognitive processing of information of the selected stimuli, but lot of time the information that is unattended and without conscious awareness affects our behaviour significantly.

There have been numerous claims that there is no causal relationship between attention and consciousness. However there have been few evidences obtained which shows that attention can also be drawn to various unconscious stimuli. Lamme has proposed one model to explain how attention and consciousness work together. According to this model the sensory input obtained from the environment is separated into conscious and unconscious category. The one which we attend is available for conscious report (Gilhooly et al., 2014). The difficulty experienced is between drawing a boundary between conscious and unconscious frames. Lammes' model talks about feedforward sweep and recurrent processing. Feedforward sweep is when the visual signal input is travelling forward and does not go back. In recurrent processing the signal input traverses back and forth from one visual stimuli to other and there is exchange of information taking place. So from lower area of the brain to higher areas of brain exchange of information takes place. The feedforward sweep corresponds to unconscious where the information is processed by the brain but it does not get into our conscious awareness whereas recurrent processing would create conscious experience.

4.5 CONSCIOUSNESS AND BRAIN ACTIVITY

With the enormous growth of research in the field of consciousness and attention, newer empirical evidences are being obtained from the other related field. With the use of modern techniques, such asbrain imaging, the wider relationship between consciousness and brain activities is being explored. So, in the further section let us see how neuropsychology field investigates the relation between consciousness and different brain regions.

Neuropsychology:

There have been plethora of studies on individuals with brain damage. As we all know individual brain comprises of two hemispheres right and left, which is well connected by a brain structure called corpus callosum. Researcher Roger Sperry has conducted research on patients with severed corpus callosum in order to control epileptic seizures, to study the process of consciousness (Gazzaniga, 2005). Michael Gazzaniga conducted a series of experiments with split-brain patients. When he showed the split-brain patient few shapes to the right eye, he found that left brain processed information and patient could describe what he saw verbally. When the same image was flashed by Gazzaniga to the patient’s left eye, the patient reported of seeing nothing, verbally, however, he could point at the object as well as draw what he saw but could not describe anything verbally. This was breakthrough research that informed us about lateralization functions being performed by both the hemispheres, where left hemisphere controls the right side of the body and right hemisphere controls the left side of the body. Through his split brain experiments he found that there exists two consciousness that are trying to understand world their own way. However, later studies have contradicted this view which claims that split brain does not split consciousness (Yair Pinto, 2017).

Another area in the field of neuropsychology is related to blind sight. Blind sight is a form of damage to the visual cortex region of the brain, which performs important, complex functions of perception, attention and consciousness (Sahraie et al., 2006; Weiskrantz et al., 1974). Due to blindsight, an individual is unable to consciously report the object or stimuli that they see, but they can point out or respond to the stimuli in some ways. People with blindsight consistently deny awareness of items in front of them, but are capable of responding to it in different ways (Henry Taylor). There are two types of blind sights, Type I and Type II. In Type I blindsight there is complete absence of any conscious awareness of objects to the damaged area, whereas in Type II there is some weak level of conscious awareness exists that helps in detection of movement. There have been criticisms raised over the issue of blindsight and more amount of new research is needed to understand how visual information does not get into conscious awareness in patients with blindsight and what happens in case of normal individual.

Neural Correlates Of Consciousness (Ncc):

Investigation of NCC research was carried out by German American neuroscientist Christof Koch. He has done an important research work in understanding mechanisms of visual attention and also exploring neural basis of consciousness. The NCC approach aims at finding, the minimum amount of neuronal sets or brain activities, sufficient to give you the perception of conscious experience. However, the complexity lies in studying different types of stimulus material giving rise to different conscious experience and the role different brain areas play in making this conscious experience available to us.

In an experiment demonstrated by Leopold & Logothetis, 1996 on NCC, which was carried out on monkeys, in order to study the function of NCC in binocular rivalry (experience of seeing one image when different images are shown simultaneously to two eyes), two different images were presented to different eyes simultaneously.This resulted in seeing one image followed by seeing the other image, and later the simultaneous appearance of both the images. This led to brain activity in primary visual cortex to a certain extent and as and when both the images came into experience then cells in the inferior temporal cortex. Thus for consciousness to occur for visual stimuli, the role is played by primary visual cortex as well as some parts of inferior temporal cortex play a role.

Thus, from the above presented views of consciousness one can realize that both consciousness and attention are entwined with each other. We have also found evidence-based data regarding different regions of the brain involved in conscious experience.

4.6 SUMMARY

In this unit we have seen various categories of attentional failure. One of them being inattentional blindness where the individual is unable to notice a clearly visible target due to attention being diverted from the target. So in a movie when different scenes are edited and the movie is run, the viewer is unable to track the difference between two scenes, this is where the concept of inattentional blindness could be seen. Another type of attentional failure is change blindness, where some sensory input or visual stimuli that undergoes changes is gone unnoticed by the viewer.

ADHD is another condition where attentional failure could be noticed. Individuals have great difficulty in focusing their attention for sustained period of time due to various reasons relating to brain chemistry.

There are also various neuropsychological reasons for attentional failure, one such condition is known as hemineglect where damage to the right parietal lobe makes an individual completely neglect the left side of their body and area that falls to the left. Studies on several patients conducted show that these individuals respond to daily tasks in such a way that they would completely ignore all left side tasks such as eat food only from right side, copy images of simple objects only of right side etc. This is again due to problems in attention.

Divided attention could be seen when individuals are trying to complete two mental tasks simultaneously. There have been lot of discussions on whether division of attention is possible or are there quick shifts in attention happening from one task to the other.

Logan and Etherton came up with important assumption of attention known as attention hypothesis of automatization. They carried out experiments to answer the above assumption that if we do not pay attention during the learning phase then learning will not take place. According to this hypothesis, attention is needed during a learning or practice phase of new task and also takes into consideration what will be learned during the practice phase, and at the same time, what will be remembered because of practice.

A key concept to both attention and consciousness is selection. In case of attention selection helps us to allocate different mental resources to complex mental tasks requiring attention, whereas in case of consciousness, selection enables us to understand how certain tasks come under the threshold of awareness during cognitive processing and how certain tasks remain unconscious. Humans possess this amazing ability of consciousness which helps them to understand and introspect themselves, assess their feelings, control their behaviour and process higher order information. Consciousness can be distinctively expressed to perform two broad functions, namely conscious inessentialism and epiphenomenalism. In conscious inessentialism, consciousness is not needed to perform complex cognitive tasks whereas as per epiphenomenalism consciousness has no function to perform.

Volition or 'free will' can be applied consciously or over a period of time it can be automatized through habit formation. The ability to stay focused on certain tasks and bay off interferences or distractions is volition.

The Global workspace theory (GWT) proposes that consciousness requires interaction across a broad range of brain areas. It resembles the concept of working memory. According to researcher Baars, nonconscious processes from different brain regions are polled together, and most popular among them is ignited into conscious experience through cerebral cortex.

Attention and consciousness seem to be so entangled with each other, that one cannot think of consciousness and attention being studied independently. Researchers have been divided over the view that attention and consciousness are two distinct processes that perform distinct functions. One can become conscious of things without attending them.

Neural correlates of consciousness, throws insight upon the role of different brain activities initiated during conscious experience.

4.7 QUESTIONS

Q.1 What is attentional failure?

Q.2 What is division of attention? And is divided attention possible?

Q.3 What is attention hypothesis of automatization?

Q.4 Explain consciousness in detail.

Q.5 Does consciousness have any function to perform? Support you answer with suitable data.

Q.6 Discuss the role of attention and conscious.

Q.7 Write short notes on:

a. inattentional blindness

b. change blindness

c. global workspace theory

d. neural correlates of consciousness

4.8 REFERENCES

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5

SENSORY, SHORT-TERM AND WORKING MEMORY - I

Unit Structure

5.0 OBJECTIVES

After studying this chapter students will be able to:

- Understand the characteristics of sensory memory
- Differentiate between the types of sensory memory
- Learn how the short-term memory is organized
- Understand the functioning of short-term memory

5.1 INTRODUCTION

Memory is a cognitive process that is used in a variety of tasks and situations in our day-to-day life. It is involved in almost all the tasks that we need to perform such as locating in which shelf the sugar or salt jar has been kept, doing the bank work, remembering the names of the school friends or recalling information while writing the answers in an exam. Hence, memory is one of the most important cognitive processes.

The three most important functions of the memory are to encode, store and to retrieve information. Encoding refers to the process by which the obtained information is converted into a form that can be stored in the memory and utilized by other cognitive processes when required. Storage refers to the process of holding or retaining of the information in memory that can be used later whereas retrieval is the process by which the stored information can be recollected or obtained when needed.

Understanding the organization and the functions of memory has been a topic of interest among the researchers for ages. Memory was analogized to that of a huge box, a cabinet and even a warehouse. Over a period of time, as the technology advanced, the psychologists started comparing the memory structure to that of a telephone structure and later to that of the computer systems. Just as a computer processes the fed information and gives the output, it was believed the memory processes function in a similar manner.

Two broad divisions of memory include short-term memory (STM) and the long-term memory (LTM). The two differ with respect to the amount and duration of the information stored. LTM is a relatively permanent storage that holdsvast amount of information for a long period of time. It involves memory for factual information like the name of the capital of India, memory for specific episodes or events like a friend's birthday party or wedding, memory for certain procedures like how to tie shoelaces or how to brush your teeth. The information stored in LTM can be accessed or recollected when needed. The STM holds small amount of information that is temporarily accessible for a short period of time. Example of STM would be remembering a phone number or an address that has been just recited to you before you can write it down.

Another component of memory is the Sensory Memory. Before the information enters into the STM, it is held very briefly in the sensory memory. It involves all the information that enters from the sensory modalities (sight, smell, sound, taste and touch) and is registered temporarily. Examples of sensory memory are seeing a red bus pass by, smell of soil after rains, hearing a doorbell, etc.

A little later identified but one of the very important component of memory is the Working Memory (WM). It is that component of the memory which helps us to hold and manipulate the information while we are performing a particular activity or a task. For example, mentally solving a sum, or remembering and writing an answer during the exam.

5.2 SENSORY MEMORY

At any given point in time, we are surrounded by a number of things or events or people in our immediate environment. All these stimuli are being absorbed by the receptors of our sensory organs. This sensory information from the different sensory modalities is transferred to the sensory memory which is a brief sensory register to process the relevant aspects of that information. Although the capacity of the sensory memory is quite large ; the information that is not attended fades very rapidly. Out of all the stimuli that bombard our sensory modalities at any given point in time, only the ones that are paid attention to enter short term memory.

Sensory memory registers information from all the five sensory modalities and it consists of different stores for modality-specific information - the Iconic Sensory Memory stores visual information, Echoic Sensory Memory stores auditory information, Tactile or Haptic Sensory Memory stores touch-related information, Olfactory Sensory Memory stores information pertaining to smell and taste related information is stored by Gustatory sensory Memory. In this section we are going to discuss about the first three types.

5.2.1 Iconic Memory:

The Iconic memory or the Icon is the type of sensory memory that holds information of visual stimulus for a brief period of time. The term Iconic Memory was coined by Neisser in 1967. Sperling (1960) conducted a series of experiments related to visual memory span to study the characteristics of the iconic memory. In his experiments, Sperling presented the participants with a stimulus consisting of three rows of alphabets; each row containing four letters. This stimulus was presented for a very brief period of 50 milliseconds.

R C H L

Q V T E

M X P D

Initially, the participants were asked to recall and report as many letters as they could. This was called the 'whole-report' condition. It was observed that the participants could on an average report only 4-5 letters (out of 12) in this condition. In the later part, the participants were asked to report only a specific row or array of letters. This was called the 'partial-report' condition. In this condition each row was associated with a particular signal tone. The top row was associated with high-tone signal, the middle row was associated with medium-tone signal and the bottom row was associated with a low-tone signal. The participants had to recall and report the letters of a specific row depending on the tone presented.

The participants did not know beforehand which row of letters they would be asked to report and it was found that they could on an average report 3 letters from each of the row. This finding suggested that a large amount of information was available to the participants as they could recall letters from each row when asked. Even when the number of letters in the stimulus array increased, the participants could still register increased amount of information in partial report condition and yet they could report only 4-5 letters in the whole-report condition. The reason for this could be that as the participants were reporting the first few letters, they lost information about the remaining letters. This finding implies that the iconic memory can hold vast amount of visual information information for a very brief time.

Sperling also studied the speed of decay of the information from the iconic memory by increasing the time span between presentation of the array of letters and the following signal tone. The results indicated that even a delay of half a second caused loss of information, suggesting that the decay of information from the iconic memory is very rapid. The above results were supported and confirmed by a number of experiments conducted subsequently by other psychologists.

In another version of his experiment, Sperling used an array of stimulus that included both letters and numbers and introduced a new partial report condition in which the participants had to report only the letters or the digits from all the arrays of stimulus. A specific type of tone was cued for the letters and for the digits. The results showed that in this type of partial report condition, the participants could report only about 4-5 items just as that in the whole report condition suggesting that the ability to report by category is same as reporting whole stimulus location wise.In other words, participants couldn't differentiate between the categories and they were processed as whole. This finding throws light on another important characteristic of the sensory memory: information held is not categorized or manipulated and that further cognitive processing does not happen unless the information is transferred to the short-term memory.

The function and the characteristics of the iconic memory could be best understood with an example of watching a movie. The movie projector projects a series of static images onto the screen rapidly. However,as the previous static image is still available in iconic memory while later image appears, we perceive it to be continuous motion picture. Thus, iconic memory allows experience of visual input to be prolonged.

5.2.2 Echoic Memory:

The sensory memory for the auditory information is called the Echoic Memory. In simple words, it is the auditory counterpart of the iconic memory. Just as the term iconic memory, the term echoic memory was also given by Neisser in 1967. Initially, Moray, Bates and Barnett (Moray et al., 1965) conducted an experiment to study the echoic memory which was based on the Sperling's partial report technique. Darwin, Turvey and Crowder (Darwin et al., 1972) extended and improved Moray et al.'s experiment further which helped to better understand the characteristics of the echoic memory.

In their experiment, Darwin et al. presented the auditory stimulus to the participants by using the stereo headphones so as to present the sounds in three spatial positions – left, right and middle (stereo). The stimulus sequences were formed using nine alphabets (letters) and nine numbers. Three items were presented to through the left channel, three items from the right channel and three items were presented through the stereo.

Left: 2 P H

Middle: R 3 G

Right: A T 1

The items were presented in such a way that the first item of each channel will be heard simultaneously, followed by second item for each channel and then the third. In the above example, the participants would first hear 2, R, A, then P, 3, T and finally H, G, 1 simultaneously.

A visual cue was presented for the left or middle or right channel and the participants had to report what they had heard from that respective channel. After the presentation of the auditory stimuli; the visual cue was indicated (so that the participants know which set of items they have to report) with a delay that varied from 0 to 4 seconds. It was found that, for the delay of zero seconds the participants could report about 5 to 9 items whereas after the delay of four seconds the participants could report only 4.25 items, on an average.

The findings from the above experiment were similar to that of the Sperling's experiment suggesting that the echoic memory functions similar to that of the iconic memory. Basically, the results suggests that the initial memory for the auditory information is quite large but the decay happens rapidly. The acoustic register of echoic memory allows for presented information to be prolonged so that some items can be sent for further processing.

Glucksberg and Cowan (1970) conducted an experiment using the shadowing technique. In shadowing technique, the participants are asked to repeat the information or message that is presented in auditory format in either of the ear. The participants were asked to shadow a message presented in one ear while another message was being presented in the other ear.

The participants had to ignore the message presented the other (unattended) ear. However, they were instructed about numbers being presented in between test information and when a light cue would be presented they will have to report the number they heard last in unattended ear. The duration of time between the presentation of the number and the light cue was varied between 0 to 4 seconds. It was found that the performance on this task deteriorated as the time increased to 4 seconds. This again confirms that the information from the echoic memory decays rapidly.

The information in the sensory memory is subject to rapid disruption when the target information is masked by another information causing the decay of target information. Masking occurs when a second piece of information is presented immediately after first piece of information, thereby sort of covering or masking the initial information.

Cowan(1984,1988) suggested that there are two stages of sensory memory – the first phase is the pre-perceptual phase which is relatively shorter, lasting for about 250 milliseconds whereas the second phase involves considerable processing which is comparatively longer and can last for several seconds.

The important characteristics of the sensory memory based on the observations and the results of the series of experiments conducted on iconic and echoic memory are as follows:

- The sensory memory can hold large amount of information
- The sensory memory can hold the information only for a brief period of time

- The loss or decay of information from the sensory memory occurs very rapidly
- The information in the sensory memory is unprocessed and for further processing it needs to be transferred to STM
- The information in the sensory memory can be easily disrupted by the subsequent information, before it gets transferred to STM

5.2.3 Haptic Memory:

The Haptic Memory is the sensory memory for the information perceived through the sensation of touch. Bliss et al. (1966) conducted an experiment to understand the characteristics of haptic memory, using the partial report technique. First the participants were trained to associate an alphabet with each of the three sections of the four fingers of one hand. Next, the participants had to place their hand on a device that released a puff of air on some of the sections of the fingers.

The task of the participants was to report the letters that was associated with those sections of the fingers depending on the visual cue presented. Each section of the fingers (upper, middle and lower) was associated with a visual cue. In the partial report condition, the participants had to report the particular letters whose sections were associated with the specific visual cue. The results showed that, the performance was better when the visual cue was presented within 800 milliseconds after the presentation of the tactile stimulation. The results were consistent with the other experiments done on the visual and auditory sensory memory.

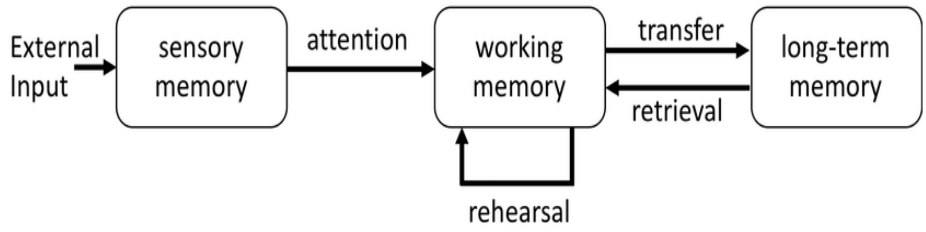
Thus, the research in this area confirms that the sensory memory provides a temporary memory of large amount of incoming sensory information. The information from sensory memory is brief and unprocessed and for the further processing of the information, it has to be transferred to the STM.

5.3 SHORT TERM MEMORY (STM)

Suppose that you are travelling in a bus and you are reading through a novel. As you are completely engrossed in reading the book, the passenger on your adjacent seat interrupts you to ask about an address and its nearest bus-stop. You would close the book and listen to the address; in case you know the location, you would direct the person accordingly or in case you don't you would say so. In any case, the conversation would last for a brief period of time after which you would go back to reading the book. When you re-open your book, you would remember the page number and the paragraph that you were reading before you were being interrupted by the other passenger. This could be achieved with the help of the Short-term memory (STM). The STM holds a small amount of information, in an active form for a short period of time. In other words, it is a temporary storage for the active information while holding the information in our awareness.

Atkinson and Shiffrin (1968) put forth the Modal model of memory. They proposed that there are three memory stores sensory memory, short-term memory and long-term memory. This model of memory was based on the computer metaphor. According to this theory, the information first enters the sensory memory, the relevant aspect of that information which receives attention gets transferred to short-term memory where it is processed and finally stored in the long-term memory via rehearsal.

Atkinson & Shiffrin Model of Memory



The information in the STM is susceptible to 'decay' which is a process of loss of information over a period of time. The information from STM could also be lost through 'displacement' which is a process in which the incoming information causes the loss of previously held information in the STM.

For the information to get transferred from STM and to be stored in the LTM, it needs to be processed further. One such method is 'Rehearsal' which involves repeating the information to oneself. 'Maintenance Rehearsal' involves simply repeating and holding information in STM as it is and 'Elaborative Rehearsal' involves manipulating and organizing the information to be stored in LTM so as to be retrieved and utilized when required.

5.3.1 Capacity:

The evidence for the functional limit (capacity) of STM came from the Digit Span tasks. In this task, the participants are presented with a series of digits in increasing lengths(for eg., 2 digit series such as 7-4 then 3 digit series such as 5-9-2 then 4 digits series like 6-9-1-7, so on and so forth) and are asked to repeat the digits in the same order as they were presented to them. As the length of the series of digits goes on increasing the task becomes more and more difficult and the participants are unable to recall the digits in the correct sequence.

George Miller (1956) suggested that the capacity for holding information in the STM is 7 plus or minus 2, he called it 'the magical number', stating that people can on an average hold 7 items in the STM ranging from 5 to 9 items depending on the various other factors like personal factors, situational factors, the nature of information etc. He further stated that the 'items of information' or 'chunks' could be digits, alphabets, words, sentences, paragraphs or poems.

Chunking of information is a technique which involves grouping the smaller units of information into larger units in order to improve the memory. Many of us remember our phone number in 5 chunks of 2 numbers instead of 10 separate numbers, which is a daily life use of chunking method.When used for STM, chunking improves its capacity. Using information from the LTM can facilitate the process of chunking.

The following number sequence can be viewed as 8 individual numbers or we could arrange and group them in the date format which makes it easier to recall them.

15092021 (Before chunking)

15/ 09/ 2021 (After chunking)

5.3.2 Coding:

Coding refers to teh form in which the information is processed in order to be stored in the memory. Conrad (1964) presented the participants with a list of consonants that had to be recalled later. The letters were presented visually to the participants; however, it was found that they were more likely to make errors with the letters that sounded similar to that of the originally presented letter.

For example, if the participants were presented with the letter P and they made an error in the later recall; they were more likely to report the letter that sounded similar to P (V) than report a letter that looked similar to P (R). Even though the original presentation of the consonants was visual, the participants were confused with the sounds because the participants were mentally representing the stimulus auditorily rather than visually. Thus, the dominant coding used in the STM is auditory or acoustic in nature.

5.3.3 Retention duration And Forgetting:

The length of the time the information is held in STM is called the retention duration. The retention duration of STM was studied through the Brown-Peterson task (Brown, 1958 and Peterson & Peterson, 1959). The participants were presented with trigrams (combination of three consonant letters like PJK or three-digit numbers like 738). After the stimulus presentation participants were asked to count backwards by 3, in a loud voice, 2 counts per second(for eg., 60-57-54-51-48…) The length of the time the participants were supposed to count varied between 3 seconds and 18 seconds. The counting backwards task was meant to prevent rehearsal of the trigram shown.

When the length of time for counting backwards was 3 seconds, 80% of the participants could recall the trigram while as the length of time was increased to 18 seconds only 7% of the participants could recall the trigram. One explanation for these results can be attributed to ‘decay of the memory trace’. If the mental representation of the presented information is not rehearsed, the information decays in about 20 seconds.

Another explanation for it can be attributed to ‘interference’. One information could displace the other information making it difficult to retrieve the former information. The counting backwards task interferes with the memory trace for the trigram by taking away for its rehearsal which eventually causes the information about the trigram to decay.

Keppel & Underwood (1962) identified a type of interference called as Proactive interference. It refers to the fact the information that was learnt prior can interfere with the retention of the subsequently learnt information. However they also suggested that if the new information is very distinct from the earlier then the degree of interference can decline drastically, a phenomenon called as release from proactive interference.

Thus, it can be concluded that the forgetting from the STM can be explained by different mechanisms and by combination of both the mechanisms of decay and interference.

5.3.4 Retrieval Of Information:

Sternberg (1966) conducted a series of experiments in order to investigate how does the retrieval of information from STM takes place and whether the search for information happens in a serial or in parallel manner, and if the search is self-terminating or exhaustive in nature. In his experiments, the participants would be asked to locate a target letter out of a set of multiple letters presented as a stimulus.

In parallel search, the comparison of the target information against the whole set of information held in the STM is done at the same time therefore this type of search takes less time as all the information is searched at the same time(similar to scanning a whole picture at the same time). In serial search, the set of information held in STM will be searched and compared one at a time to the target stimulus and hence more the information, longer the time taken to search the information(similar to scanning a picture item by item).

In self-terminating search, the process of search stops when the target information is found. Whereas in the exhaustive search, the search will continue till the entire set of information has been verified. Sternberg argued that the retrieval of information from the STM occurs in serial, exhaustive manner and at a very rapid speed. Other studies found that the search retrieval from STM happens in a parallel manner. It can be concluded that the memory processes work differently for different types of information (stimulus).

The characteristics of STM can be summarized as follows:

- STM holds information for short period of time
- STM can hold limited amount of information
- The information in the STM is encoded acoustically
- The information in the STM is maintained with rehearsal
- The retrieval of information from STM follows rapid serial, exhaustive search
- The processing of the stored information depends on the nature of the information.

A lot of studies were conducted to provide evidence for distinction between STM and LTM, that they are two distinct memory stores. The evidence for distinction between the STM and LTM was noted with a phenomenon called the 'serial position effect'. In these tasks, the participants are presented with a list of unrelated words in an auditory manner and asked to report the words that they remember in any order. It was found that the recall was relatively good for the words presented at the start of the list (called as primacy effect) and that for the words presented at the end of the list (called as the recency effect) as compared to the words presented at the middle of the list.

The recency effect occurs at the items are still held in the STM, whereas the primacy effect occurs because those items have been transferred to the LTM. But as more and more items are presented one after other, there is less time for them to get transferred to the LTM. Thus, these middle order items get displaced from the STM, but are not transferred to the LTM successfully. These findings support the distinction between the STM and LTM.

Another evidence supporting the distinction between STM and LTM was noted by the 'double dissociation of function'. The double dissociation of function between the STM and the LTM was identified through the studies on people with amnesia (memory loss) following brain injury. It was found that some patients with amnesia have intact STM functioning while the LTM functioning was impaired whereas in other patients have impaired functioning of STM but the functioning of the LTM is intact, thereby indicating separate functioning of the two components.

5.4 SUMMARY

Memory is a cognitive process that we tend to use in a variety of tasks and situations in our day-to-day life. The three most important functions of the memory are to encode, store and to retrieve the information. Initially memory was analogized to that of a huge box, a cabinet and even a warehouse. Over a period of time, the psychologists started comparing the memory structure to that of the telephone structure and later to that of the computer systems.

There have been two broad divisions of memory; namely the short-term memory (STM) and the long-term memory (LTM). LTM involves all the information that is held for a long period of time. The STM holds small amount of information that is temporarily accessible for a short period of time. Before the information enters into the STM, it is held very briefly in the Sensory Memory. Working Memory (WM) is that component of the memory that helps us to hold and manipulate the information while we are performing a particular activity or a task.

Sensory memory registers information from all the five sensory modalities and it consists of different stores for modality-specific information. The Iconic memory or the Icon is the type of sensory memory that holds information for visual stimulus for a brief period of time. The sensory memory for the auditory information is called the Echoic Memory. It is the auditory counterpart of the iconic memory. The Haptic Memory is the sensory memory for the information perceived through the sensation of touch. Sensory memory holds large amount of information for a brief period of time and is susceptible to rapid decay.

Atkinson and Shiffrin (1968) are credited for the Modal model of memory. The model proposes that there are three memory stores namely sensory memory, short-term memory and long-term memory.

The STM holds a small amount of information, in an active form for a short period of time. It is a temporary storage for the active information while holding the information in our awareness. The characteristics of STM can be summarized as, STM holds limited amount of information for short period of time, that is encoded acoustically and maintained with rehearsal. The retrieval of information from STM follows rapid serial and exhaustive search and the processing of the stored information depends on the nature of the information.

A lot of studies were conducted to provide evidence for distinction between STM and LTM, that they are two distinct memory stores. One of the important evidence is a phenomenon called the 'serial position effect' which is of two types. The recency effect(better memory for items presented at the end of the list) occurs as the items are still held in the STM, whereas the primacy effect(better memory for the items presented in the beginning of the list) occurs because those items have been transferred to the LTM.

The observation that some patients with amnesia have intact STM functioning while their LTM functioning is impaired whereas in other patients have impaired functioning of STM but the functioning of the LTM is intact provides another distinction between STM and LTM, a phenomenon called as'double dissociation of function'.

5.5 QUESTIONS

1. Write a note on Modal model of memory.
2. Discuss the different types of sensory memory
3. What are the functions of sensory memory?
4. Explain the characteristics and functioning of STM in detail
5. Write a note on Iconic memory
6. How is the short-term memory organized?
7. Write a note on Echoic memory
8. Explain distinction between STM and LTM with supporting evidence.

5.6 REFERENCES

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6

SENSORY, SHORT-TERM AND WORKING MEMORY - II

Unit Structure

6.0 OBJECTIVES

After studying this chapter students will be able to:

- Understand the characteristics of working memory
- Differentiate between the different components of working memory
- Learn the functions of the different components of working memory

6.1 WORKING MEMORY

Miller (1960) introduced the term 'Working Memory' (WM). Working memory is similar to STM in terms of the storage. WM allows us to hold the information temporarily so that it is accessible to us while performing a mental task such as solving sums or answering a question. Based on the different theoretical viewpoints put forth, the WM can be viewed as follow:

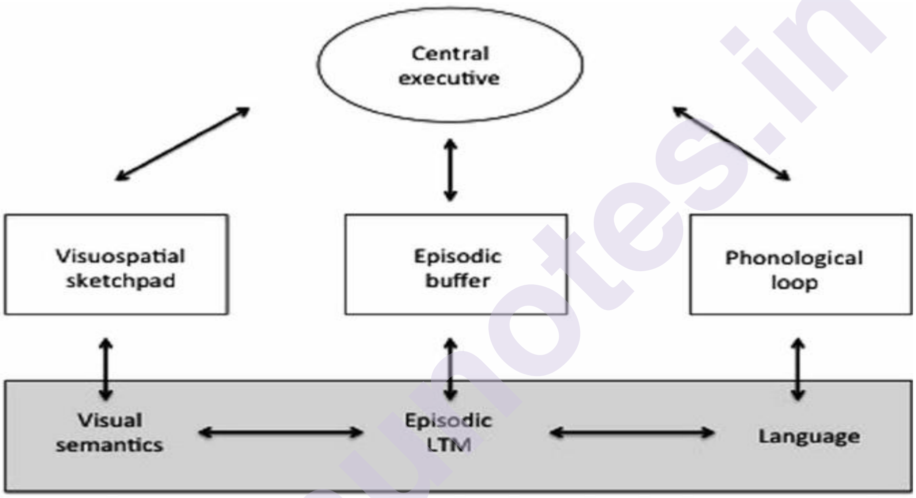
- The focus of attention
- The temporarily activated information about the current task
- Memory system that facilitates short-term storage and processing of the information.

Cowan (1995, 1999) put forth the Embedded Processes Model for WM. This model emphasizes the interaction between attention and memory. It views WM as the memory within the focus of attention, having limited capacity and a temporarily activated part of the LTM. This means that the information is not currently in the consciousness but can be retrieved when required. The cause for loss of information from the WM can be attributed to both decay and interference.

The multiple component models of WM propose that the WM can be divided into multiple subsets or components. These theories suggest that the WM simultaneously stores and processes information. Therefore it consists of both the storage and processing components. The most appealing model of the WM was put forth by Baddeley & Hitch in 1974.

6.2 BADDELEY'S WORKING MEMORY MODEL

Baddeley's Working Memory Model



According to Baddeley, the WM is not just a store for holding up information in conscious awareness but it also plays a significant role in the processing of the information for any of the cognitive tasks. The WM was viewed as a 'workspace' that has limited capacity and comprising of multiple components – the central executive, the phonological loop, the visuo-spatial sketchpad - and the later added component – the episodic buffer (Baddeley & Hitch (1974), Baddeley (1986 & 2000)).

The Central Executive is manager of all the other components. It controls and co-ordinates other components of the WM. It provides the attention resources to the various components. It is modality free and can deal with any kind of sensory input. The modality-specific information is served to the central executive through the specialized sub-systems.

There are two important sub systems functioning under central executive. The component dealing with visual-spatial information is called as the Visuo-spatial sketchpad and the one dealing with auditory-verbal information is named as the Phonological loop.

6.2.1 The Phonological Loop:

The phonological loop is the component that is specialized for speech-based, verbal information. This component was earlier named as the 'Articulatory loop'. Baddeley (1975) proposed that articulatory loop has limited capacity which is restricted by temporal duration and it can hold as much verbal information as a person can say for about 2 seconds.

The phonological loop has two sub-components – the phonological store and the articulatory control process. The phonological store holds the speech-based information for 2 to 3 seconds (if not rehearsed) whereas the articulatory control process facilitates the holding of information in the store and converts the visual-verbal information(for example a written word) to a speech-based form. It uses sub vocal rehearsal(hearing one's own thoughts while reading, for example) to complete this task.Thus, the auditorily presented speech-based information has direct access to the phonological loop however, the visually presented information gets access through the articulatory control process.

The word length effect:

The word length effect refers to the advantage in the recall of words which are shorter in length as compared to the words which are longer in length. According to Baddeley, we can remember as many words as we can say in 2 seconds; then a greater number of words can be remembered if they are shorter (cake, pull, up, in, out) as compared to longer words (engineer, independence, occupation).

The determining factor is the length of time required to articulate the word and not the number of syllables in the word. The longer words require more time to rehearse by the sub-vocal articulation and hence only fewer words can be accommodated in the phonological store.

The effects of articulatory suppression:

The disruption in the ability to rehearse an information sub-vocally when asked to rehearse an irrelevant word out loud is called the articulatory suppression. The articulatory suppression not only decreases the span of memory but it also eliminates the word length effect.

It interferes with the transfer of the visual-verbal information to the phonological store causing poor memory. Rehearsal of an irrelevant word depletes the resources and the capacity of the articulatory control process which further prevents the refreshing of information in the phonological store thereby affecting the performance on the task.

The irrelevant speech effect:

Presenting irrelevant speech during the learning of information affects the recall of the visually presented verbal material. This effect is elicited by any speech sounds, presenting irrelevant speech in any unfamiliar language can also affect the performance. (For example, the difficulty that you experience when reading a book while someone in your room is talking over a phone call that you can hear)

The irrelevant speech presented uses up the available resources in the phonological store and interferes with the performance.

The phonological similarity effect:

The recall for the list of verbal items that sound similar (nap, pan, map) will be poor as compared to the list of verbal items that do not sound similar (bat, pen, dig). However, this effect is not seen for the words having similar meaning. Since, the phonological code is used to process the words; as the number of shared sounds increases, the confusion also increases, thereby affecting the recall. The phonological similarity effect is not applicable to the articulatory suppression.

It could be assumed that the WM plays a significant role in the language use and its related cognitive processes, because the phonological loop is involved in holding and manipulating the speech-based information. However, Baddeley (1992) observed that people with brain injury who have impaired functioning of the phonological loop exhibit very few signs of general cognitive impairment.

Studies have found that phonological loop plays a significant role in the acquisition of new vocabulary in not just one's native language but also while learning foreign language. Poor phonological loop functioning is associated with low speech comprehension in adults and in children it is associated with poor learning of vocabulary. The phonological loop also plays a role in the temporary holding of information about the solutions while performing mental arithmetic calculations.

6.2.2 The Visuo-spatial Sketchpad:

Just as the phonological loop is specialized to deal with the speech-based information, the Visuo-spatial Sketchpad (VSSP) is specialized to deal with the visual and spatial information. VSSP is that component of the WM that facilitates the ability to manipulate the visual images and is dependent on the visual short-term memory. The VSSP too has a limited capacity for 3 or 4 objects.

The VSSP consists of two components – a visual cache and an inner scribe (Logie, 1995). The visual cache stores and deals with information about the visual form whereas the inner scribe facilitates the spatial processing. The visual cache is similar to that of the phonological loop (which stores or holds the information) and the inner scribe is similar to that of the articulatory control process that facilitates the maintenance of the information through rehearsal.

<u>Matrix Task:</u>

Brooks (1967) developed a matrix task to demonstrate how the processing occurs in the VSSP. The participants were given some sentences to memorize, these sentences were either easy to visualize or they could not be visualized. In the first condition (spatial condition), the sentences were presented along with a 4 x 4 matrix which could aid the memory. Memorizing sentences required phonological loop of WM. The sentences were as follows:

- Put a 1 in the starting square
- Put a 2 in the next square to the right
- Put a 3 in the next down square

In the latter condition (verbal condition), the sentences were presented that could not be visualized. So, the 'spatial' adjectives up, down, right, left were replaced by non-spatial adjectives like good, bad, slow, fast.

- Put a 1 in the starting square
- Put a 2 in the next square to the good
- Put a 3 in the next slow square

Participants were asked to memorize and recall the sentences. In the spatial condition, participants could recall about 8 sentences and in the verbal condition the participants could recall 6 sentences.

The performance for the auditory and visual presentation of the sentences was compared and it was found that for spatial task, auditory presentation worked better and for verbal task, visual presentation worked better. In the spatial condition, the auditory presentation of sentences facilitates the VSSP to perform better while in the verbal condition the visual presentation of the sentences facilitates the phonological loop to perform better on the primary task.

Dual Task Performance:

In 1975, Baddeley developed a dual-task which was designed to interfere with the performance on the Brooks task. The participants were presented with the sentences auditorily and were told to track a moving target with the help of a hand-held stylus at the same time. In this dual task, the performance in the spatial condition was affected but not in the verbal condition.

Baddeley & Lieberman (1980) extended the task further by using two secondary task conditions to distinguish the difference between the visual and the spatial components. The sentences were presented auditorily in both conditions. In the first condition, the participants were given a task that related to visual processing involving making brightness judgments. In the second condition, the participants were blindfolded and asked to track a pendulum with a torch. The pendulum when came in contact with the torch light would emit an auditory tone. The results indicated that the performance was largely affected in the spatial (second) condition as compared to the visual (first) condition.

Patients with bilateral damage to the occipital-temporal region of the brain but with no damage to the parietal lobecould perform better on the spatial tasks as compared to visual tasks. Whereas, patients with damage to the right parietal lobe and right temporal lobe could perform better on the visual tasks but not on tasks requiring spatial processing. The data from the neuro-imaging studies have confirmed the dissociation between visual and spatial processing by identifying separate areas of the occipital, parietal and frontal lobes involved in each of the processes.

6.2.3 The Central Executive:

The most significant part of the working memory, handling all the complex tasks is called the central executive. According to the Baddeley & Hitch's model, the central executive performs as the supervisor which is in-charge of controlling, regulating and coordinating the functions of the other systems in the working memory. It is involved in the general processing and the allocation of the attentional resources. Hence, Caplan & Waters (1998) have described the central executive as the 'mastermind of the human cognition'.

The central executive is believed to be involved only in the processing of the information but not in the storage of the information. It may be operating through a network of sub-systems which helps in coordinating all the activities of the other components like the phonological loop and the visuo-spatial sketchpad. However, theses sub-components comprising the central executive are yet to be identified.

Norman & Shallice (1986) put forth a model; this model provides a comprehensive picture about the functions of the central executive. The model suggests that there are two types of cognitive control mechanisms – the automatic control mechanism and the attentional control mechanism. The automatic control mechanism (contention scheduling system) is used during the activities that we perform on day-to-day, routine basis and so they are operated through well-practiced actions and hence does not need deliberate or active cognitive control(like walking or buttoning shirt). The attentional control mechanism (supervisory activating system, SAS) is used to perform the activities that need deliberate and active cognitive control(like studying). Performance on these activities can interrupt the automatic control mechanism so as to channelize the available attentional capacity towards accomplishment of that particular task.

When we are walking along a familiar route say between our home and a nearby shop; we need not necessarily pay attention on the route and the details because we are habituated to it. On the other hand, when we are in a new town and we are walking along a route say between the hotel and a nearby restaurant, we have to pay attention on the route and the details because it is completely unfamiliar to us.

According to the Norman & Shallice model, the two types of cognitive control systems help to function at three levels:

- Automatic mode (for routine activities)

- Partially automatic mode (allocates attentional control for actions)
- Control mode (for novel or difficult tasks)

Patients with damage to the frontal lobe especially to the prefrontal cortex were found to have intact contention scheduling (automatic control) but had difficulty in completing the tasks that require the SAS attentional control. The type of errors resulting from the prefrontal damage are called the 'capture errors. **Capture errors** occur when we perform a routine action instead of performing another expected or intended action. For example, writing your own name in the 'Name' column while filling up a form for someone else.

People with damage to the dorsolateral prefrontal cortex usually experience impairment in the area of executive functioning. This type of impairment is called the **dysexecutive syndrome**. It refers to difficulty in controlling one's own behaviours, characterized by the inability to change or adapt the behaviour in response to the modifications or cues from the environment. One such example is 'perseveration' which is typically seen on the task in Wisconsin Card Sorting Test(task involving number of trials where some trials follow a rule and then the rule changes). Patients with damage to the frontal lobe are unable to shift the set when the rule changes and continue to operate according to the old rules and thus make errors.

The central executive is also involved in allocation and maintenance of the attentional resources for the target tasks by side-lining the other stimulus from the surroundings. Another example of dysexecutive function is the **utilization behaviour** characterized by the inability to control the actions in response to the environmental cues where the person automatically reaches to and uses the object. The studies on the patients with brain damage leading to impaired executive functioning strongly suggests that the central executive comprises of various subsystems that could probably be operating in parallel processes.

6.2.4 The Episodic Buffer:

Baddeley initially conceptualized the central executive as being involved in allocating the attentional resources and coordinating between the working memory and the LTM without having any component for storage of the information. However, the ability to store large amount of information (more than the capacity of the phonological loop) indicated that additional storage capacity is available in the working memory.

Studies on verbal learning tasks found that the memory span for unrelated words was 5 or 6 items, but when the words were presented in a sentence, the memory span expanded to 15 words. It was also found that the performance improved when the sentences presented that were grammatically correct. These findings suggest that there is a link between the LTM and the phonological loop for gathering the relevant information from the LTM regarding meaning of the information. Similar results were obtained for the link between LTM and VSSP.

In order to explain the large storage capacity of the working memory and the interaction between the working memory and the LTM, Baddeley (2000) added a fourth component to the original model of working memory. This component was called the episodic buffer. This component acts as a buffer or link between the working memory and the LTM. The characteristics of the episodic buffer are as follows:

- It acts as a workspace which is accessible to the conscious awareness
- It is a temporary storage having limited capacity
- It can hold 4 chunks of information
- It is controlled by the central executive
- It is the storage component of the central executive
- It acts as an interface between the different components of working memory and LTM.
- It also plays an important role in the retrieval of information from the LTM

Baddeley & Hitch's model of working memory provided a very comprehensive picture of the functioning of the complex memory structures and processes. The model introduced the various components and sub-systems underlying the working memory and explained how the complex cognitive tasks are accomplished. The model not only focused on the memory processes but also on the other cognitive activities like thinking, reasoning, problem-solving etc.

The model also explained about what aspects and components of the memory are affected and what aspects are spared after experiencing brain damage. These findings highlighted the fact that STM and LTM are separate memory stores, as one could be affected while the other remains intact and vice-versa. Most importantly, the model also explains the link or the interaction between the working memory and the LTM and the existence of storage capacity in the working memory.

However, on the flip side the model has not explained about the various sub-sections and underlying mechanisms of the central executive of the working memory. The inter-relation between working memory, attention and conscious awareness is yet to be understood. More exploration is needed for understanding whether and how self-efficacy can be utilized to improve the performance of the working memory.

Working Memory & Self-efficacy

The performance of the working memory can be influenced by various factors like the situational factors, factors related to the task and the personal factors like interests and emotions of the individual. One such important factor is self efficacy.

Self-efficacy refers to the person's sense of their ability to complete a particular task or achieve a goal. The role of self-efficacy and its impact on the working memory was studied in a series of experiments by Autin & Croizet (2012). The results indicated that with the help of brief psychological intervention, participants could be trained to view the task difficulty level in a positive light which can improve the performance of the working memory.

Kane et al. (2007) studied the effect of individual differences with reference to working memory. They suggested that the factors like nature of the task and the level of cognitive resources required to fulfil the task also plays an important role in determining the performance of working memory. At times, 'mind-wandering' (non-directed thoughts) could actually be spontaneous and creative and facilitate the cognitive processing in the desired direction.

6.3 SUMMARY

Miller (1960) introduced the term 'Working Memory' (WM). WM allows us to hold the information temporarily so that it is accessible to us while performing a mental task. The most appealing model of the WM was put forth by Baddeley & Hitch in 1974.

According to Baddeley, the WM is similar to that of a 'workspace' that has limited capacity, involved in both storage and processing and comprising of multiple components – the central executive, the phonological loop, the visuo-spatial sketchpad and the episodic buffer.

The Central Executive is the component that controls and co-ordinates with the other components of the WM. The phonological loop is the component that is specialized for speech-based, verbal information. The phonological loop has two sub-components – the phonological store and the articulatory control process. Visuo-spatial Sketchpad (VSSP) is that component of the WM that facilitates the ability to manipulate the visual images and is dependent on the visual short-term memory.

The VSSP consists of two components – a visual cache and an inner scribe. The visual cache stores and deals with information about the visual form whereas the inner scribe facilitates the spatial processing. The data from the neuro-imaging studies have confirmed the dissociation between visual and spatial processing by identifying separate areas of the occipital, parietal and frontal lobes involved in each of the processes.

Norman & Shallice's (1986) model suggests that there are two types of cognitive control mechanisms – the automatic control mechanism and the attentional control mechanism, these two types of cognitive control systems help to function at three levels – automatic, partially automatic mode and control mode.

To explain the large storage capacity of the working memory and the interaction between the working memory and the LTM, Baddeley (2000) added a fourth component called as episodic buffer to the original model of working memory. This component acts as a buffer or link between the working memory and the LTM.

Baddeley & Hitch's model of working memory provided a very comprehensive picture of the functioning of the complex memory structures and processes. The model introduced the various components and sub-systems underlying the working memory and explained how the complex cognitive tasks are accomplished.

However, the inter-relation between working memory, attention and conscious awareness is yet to be understood. More research will be required in the area to completely understand the functioning of the working memory.

6.4 QUESTIONS

1. What is meant by 'working memory'?
2. Write a note on the central executive
3. Discuss the characteristics of the phonological loop
4. Explain the Baddeley's model of Working Memory in detail
5. Write a note of visuo-spatial sketchpad
6. Describe different phenomenons related to phonological loop.

6.5 REFERENCES

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7

LONG TERM MEMORY - I

Unit Structure

7.0 OBJECTIVES

After studying this chapter students will be able to:

- Understand features of LTM
- Learn about two types of amnesia
- Understand the structure of LTM

7.1 INTRODUCTION

The earlier chapter focused on memories which are held for a brief period of time like fractions of second, few seconds or a minute. In this chapter we shall focus on memories which are held for longer periods of time like several minutes, hours, days, years or even for lifetime. This type of memory termed as 'long-term memory' (LTM) matches the layperson's understanding of what memory is. In this unit we shall study what LTM is, memory and amnesia and the structure of LTM.

LTM in simple words means unlimited storage of information which is maintained and can also be retrieved for a long period of time, usually a lifetime. Most common examples of LTM are your memories about some special days like your wedding or birthdays or party with your friends, so on. We may not talk about a memory everyday but when we recall it, we remember it with ease and considerable accuracy. The capacity of long-term memory is infinite. From a physiological point of view, the process of formation of LTM differs from that of short-term memory (STM). LTM is a sort of mental storehouse of memories which are formed in our everyday lives. The information that you have collected in your life is stored here.

Capacity of LTM -

Capacity of LTM is infinite and cannot be measured in number. Imagine counting your memory of all the history lessons you have learnt in school or mathematical formulas or meaning of all the words that you know along with the experiences you have in your daily life like your favorite color, songs, birthdays of your family and friends, phone numbers, movies you have seen, faces of people you know and also who you do not know, etc. The list of information you have at a particular time in your LTM can be very long and to list out every single information is beyond one's capacity. Every single thing is stored in your LTM and the information pops up when needed. Hence, it is not possible to estimate the capacity of LTM. However, Thomas Landauer (1986) tried to answer this question. He proposed that the size of the LTM in humans is equal to the number of the synapses in the region of the brain called the cerebral cortex. This area of the brain has 10^{13} synapses. Hence, few researchers believe that human beings can hold up to 10^{13} different chunks of information. However, Landauer also argued that each neural impulse may not result in memory. Hence, the estimation of the capacity of the LTM may not be accurate. Few others estimate that 10^{20} chunks of information can be stored in LTM which is the approximate number of neural impulses in the brain during a lifetime of an individual.

In any case, whatever the number may be, you cannot really retrieve or recall all the information stored in your LTM at a given moment. You may not recognize someone while crossing a street though you have met that person briefly at a party. You may also forget exact happenings of a past memory and just remember the situation indistinctly.

A 27-year-old male patient known as H.M. underwent a brain surgery in 1953 to ease his uncontrollable epileptic attacks, that involved removing the amygdala, the anterior two-thirds of the hippocampus, adjacent hippocampal gyrus and the parahippocampal gyrus (Squire, 2009). His seizures reduced to great extent however, there were unforeseen consequences which led to a great amount of memory impairment known as 'amnesia'. He could recall his childhood memory however couldn't retain the memory of ongoing events in his life. His STM was not affected; he could recall sequences of numbers or words however, could not recall any information from LTM like his doctor's names or the way to his room in the hospital (Gilhooly, et. al., 2014). The patient's linguisticability, intellect and personality to a large extent was unaffected. The patient's medical case revealed few important aspects of LTM; firstly, as earlier assumed the LTM processes are not distributed throughout the brain and damage to these specific areas will cause profound memory loss. Secondly, LTM involves a number of different abilities and even after damage to the system, some new learning can still be possible. The above-mentioned patient was able to learn new skills but couldn't recall new facts. And thirdly Squire (2009) stated that in case of this patient memory was separate for language and other cognitive abilities.

Now before we learn more about LTM and its types and processes, let us study memory and its function in the state of amnesia and how it will help us to study and understand LTM.

7.2 MEMORY AND AMNESIA

In the previous chapter and in the above section of this chapter, we read about what memory is. In this section, now we shall study about impairments in LTM, a memory disorder ; known as 'amnesia'. In cognitive psychology and neuropsychology, the term 'amnesia' refers to a condition called 'amnesic syndrome' (Gilhooly, et. al., 2014). This condition impairs LTM functioning. In simple words as put forth by Gilhooly, et. al. (2014), "amnesia refers to a pattern of memory loss affecting elements of long-term memory, while short-term memory remains intact."

Amnesia is an irreversible and prevalent memory disorder which affects several memory functions. No two patients of amnesia will have exactly same symptoms. The manifestation of amnesia in each individual will be different which largely depends on the area of the brain that is affected, the cause and extent of the damage. Parkin (1997) suggested a few general characteristics of amnesia which can be observed more or less in each patient suffering from this syndrome. The general characteristics are -

- STM is generally unaffected when assessed through digit span test.
- Memory related to language ability and concepts is largely not impaired and remains intact.
- Learning skills, priming and conditioning functions well. In most of the cases the patient will be able to engage in skills which were acquired prior to the onset of amnesia, for example, playing a musical instrument or swimming.
- A lasting and severe condition known as 'anterograde amnesia' involves memory impairment for events happening after the onset of amnesia where the patient finds it difficult to make new memories.
- The patients who have memory impairment for events that have happened prior to the onset of amnesia, the condition is known as 'retrograde amnesia' involves inability to recall old events or have old memories.

The famous 27-year-old male patient's case study which is mentioned in the introduction section of this chapter changed cognitive psychology's approach to study LTM . The following is the medical history/case study of this patient -

The patient was born in Hartford, Connecticut in 1926 and was the only child of his parents. At the age of seven, he fell due to being knocked down by a cyclist and was unconscious for several minutes (Scoville & Milner, 1957). He started experiencing minor seizures by the age of ten. The patient's family had a history of epilepsy. So, it was unclear whether he developed the condition due to that or the accident (Corkin, 2002). The patient's condition had deteriorated by the age of 16 and he experienced convulsions without warning signals on a regular basis which involved urinary incontinence, tongue biting, loss of consciousness followed by drowsiness (Scoville & Milner, 1957). He was unresponsive to medication and the severity of his condition increased over a period of time affecting his quality of life to a greater extent.

When the patient was 27 years of age, he underwent an experimental surgery which was aimed to reduce his symptoms. The surgical procedure involved removal of the amygdala, the anterior two-thirds of the hippocampus, adjacent hippocampal gyrus and the parahippocampal gyrus (Squire, 2009). The result of this operation was a dramatic decrease in seizures but the patient suffered from extreme and prevalent memory impairment, a type of memory deficit known as 'amnesic syndrome' (Gilhooly, et. al., 2014).

The patient suffered from anterograde amnesia which is characterized by the inability to retain information post-surgery. He was unable to recognize the researchers who had been working with him on a regular basis. The patient lost capability to learn new words or names of public figures whom he came across after the surgery. He would forget whether he had eaten food just half an hour after he had his meal. It seemed that he would forget the information once it left his consciousness. His memory patterns were still under study and it was observed that few parts of his memory were not affected and were still functional.

The patient also showed few symptoms of retrograde amnesia - memory loss of information which was collected before the onset of amnesia. Loss of memory over three years before the surgery was observed (Scoville and Milner, 1957). However, during later studies it was observed that retrograde amnesia was traced up to 11 years prior to the onset of amnesia (Corkin, 2002). "Retrograde amnesia tends to affect memory such that a temporal gradient is apparent: newer memories are more susceptible to disruption than are older memories, a pattern described by Ribot's law (1881) which states that - recently formed memories are more susceptible to impairment than are older memories" (Gilhooly, et. al., 2014). In accordance with this, it was observed that he could remember the seizure he had on his 16th birthday and had good memory of his childhood and adolescence days (Hilts, 1995) however, couldn't remember that his favorite uncle passed away three years back before his surgery neither could he recall or recognize the medical staff he had met before the operation (Shimamura, 1992).

This particular patient's personality, intellect, perception and language more or less remained the same. "He retained his sense of humor. When asked 'What do you do to try to remember?', hereplied, 'Well, that I don't know because I don't remember what I tried.' This also shows that he was aware of his condition" (Corkin, 2002, p. 158). The patient's IQ fell in normal range and in fact also improved a bit due to decrease in seizures (Kalat, 2007). He could converse and retain information as long as he rehearsed it in STM since his STM was intact and digit span fell in normal range. His attention sustenance was well and could remember three digits up to 15 minutes as long as he is rehearsing them; however he would lose the information as soon as his attention shifted on other tasks. He showed few signs of preserved learning. His attempts to draw a few patterns improved each day. He also could draw the floor plan of the house in which he moved in after five years of his operation. This patient's case study contributed to scientific understanding of memory processes in the field of cognitive psychology and deserves much appreciation (Corkin, 2002).

Now let us understand what is anterograde amnesia and retrograde amnesia in detail-

7.2.1 Anterograde amnesia

According to Galoti (2014), "Anterograde amnesia, which extends forward in time from the onset of amnesia, selectively affects long-term (but not working) memory, regardless of modality or type of memory test, and spares memory for general knowledge and skilled performance (although the learning of the latter will not be explicitly remembered) but can result in memories for skills that are hyper specific to the original learning context and cannot be transferred to other, similar contexts."

In other words, anterograde amnesia selectively affects LTM and has five principle characteristics (Cohen, 1997). The first characteristic is that anterograde amnesia affects LTM but not working memory. The second characteristic is that it can affect memory belonging to any modality i.e. visual, auditory, kinesthetic, olfactory, tactile or gustatory. Cohen (1997) mentions that "global anterograde amnesia results from bilateral damage to the medial temporal lobe or midline diencephalic structures; unilateral (one-sided) damage to these areas typically impairs only one kind of memory - for example, either verbal or spatial.Memory of those with anterograde amnesia is severely hampered across different testing procedures such as free recall, cued recall, recognition, etc." The third characteristic is that anterograde amnesia does not affect memory for general knowledge as such acquired before the onset of amnesia but has an overall impaired effect on recall of new events and facts. The fourth characteristic of anterograde amnesia is that it doesn't affect skilled performance, which means the amnesic patient does not forget an acquired skill like playing a musical instrument or cooking. They can be taught new skills in an amnesic state where a normal learning curve is found in their patterns of learning. The fifth characteristic states that amnesic patients may acquire new skills but those are visible only in hyper specific memories which means they can recall the learning only in extremely similar conditions in which they acquired the skill. An extreme example of encoding specificity is seen (Galotti, 2014).

7.2.2. Retrograde amnesia

According to Galoti (2014) every case of amnesia involves some amount of retrograde amnesia although its temporal extent may vary. The loss is worst for memories of information acquired closest to the time of onset. To some extent recovery of some of the lost retrograde memories is often possible.

Retrograde amnesia doesn't affect material that has been “over learned” before the onset like language, general knowledge, perceptuall, ssocial and other skills.

There are few similarities in the loss of memory like anterograde amnesia but has few key differences as well. One significant fact is all patients having amnesia will show few features of retrograde amnesia but may or may not show those of anterograde amnesia. Cohen (1997) suggested four principle characteristics of retrograde amnesia. The first one being the time span (temporal extent) of memory loss can differ in each patient having retrograde amnesia. Patients having Alzheimer’s, Huntington’s, Parkinson’s and Korsakoff’s diseases are most likely to show temporal extensive amnesia along with loss of memory that was obtained and stored for decades. Patients who had suffered closed head injury or undergone bilateral ECT show symptoms of temporally limited retrograde amnesia in which they lose memory over a period of weeks or few months. In most of the cases, especially in case of ECT, the patients fully or partially recover their lost memory. It is also observed that retrograde amnesia may be caused due to damage to the hippocampal area of the brain. The second characteristic of retrograde amnesia was seen when researchers studied particular memories that were lost. These observations were done on patients who had undergone ECT. “A temporal gradient, with the most recent memories being the most likely to be lost was observed amongst patients who had undergone ECT" (Cohen, 1997, p. 330). Full recovery of the ECT patients is mostly expected however, there are differences seen among patients who suffered from closed head injuries. For such patients retrograde amnesia slowly recovers over time with most remote memories being likely to be remembered. (Galotti, 2014, p. 224). The third characteristic of retrograde amnesia put forth by Cohen (1997) is that the retrograde amnesia usually does not affect information that was over learned before the onset of the amnesia, which means, patients have faultless knowledge about their world, language, social and perceptual skills and some general intelligence. Cases of extensive amnesia combined with dementia, however may show this loss as well. (Cohen, 1997, p. 339). And lastly like anterograde amnesia, retrograde amnesia as well spares skills learning. Even without practice, patients having retrograde amnesia tend to show a normal curve of learning and improvement.

Now that we know the characteristics and differences of anterograde and retrograde amnesia, let's study the causes of amnesia.

Amnesia can be caused due to several reasons, one being the effect of brain surgery as seen in the above case study. Few other causes include brain infection such as herpes simplex encephalitis, conditions such as Korsakoff’s syndrome, head injuries or stroke (Parkin & Leng, 1993). Korsakoff’s syndrome also known as Wernicke-Korsakoff’s syndrome is brain damage caused due to deficiency of vitamin B 12 (thiamine). In predisposed individuals, it may be due to prolonged alcohol abuse or also due to nutritional inadequacy. This situation of thiamine deficiency often goes undiagnosed resulting in losing the opportunity of administering the thiamine in time. Very often the symptoms are mirrored with those of alcohol intoxication, hence goes under diagnosed/misdiagnosed causing a severe damage. Korsakoff's syndrome is associated with damage to the mammillary body, frontal brain areas and thalamic region of the brain (Colchester et al., 2001; Kopelman et al., 2001).

Injury to the brain caused by accidents can also lead to amnesia (Squire & Slater, 1978; Teuber et al., 1968). Another cause of amnesia is an infection called herpes simplex encephalitis which is a viral infection of the brain. Within a very brief time of its onset, this infection can cause serious and extensive damage to the areas of temporal lobes of the brain. When the patient suffering from amnesia due to this infection was asked about a particular skill, he couldn't recollect whether he knew that skill, however could demonstrate the skill. This is an example of intact skills learning in the absence of conscious recollection of the same. (Gilhooly, et. al., 2014, p. 354).

Concepts and languages are generally stays intact in the patients of amnesia. The person can understand the language in which he/she speaks, can understand a question and can also recognize particular objects and its usage. But researchers argue that the foundation of language or concepts is generally laid in the early years of life. Hence, one is unsure whether the memory for language and concepts is not affected because it is collected in early years or because it is different from recollections of past events. When studying such cases, care should be taken to understand whether forgetting si happening because of amnesia or because the memory was not stored in the first place. (Loftus, 1980, p. 74).

Many cognitive psychologists and neuropsychologists believe that organization of memory is related to the study of amnesia. The fact that without disrupting STM there can be impairment in LTM which supports the idea that these two types of memory are distinct from each other. Few information-like personal details, memory about a particular incident are lost in amnesia but overlearned skills, well-practiced information may not get affected suggests that there can be different kinds of memory systems. New memories continue to undergo neurological change for some period of time, perhaps years after being formed (Galloti, 2014, p. 226). Research in this area strongly suggests that hippocampus, a structure in the brain, plays a very important role in retrieval or recall of memory for information. However, not all the LTM information necessarily involves the hippocampus.

Thus, we can say that more or less all cognitive abilities are dependent on memory. The role of memory is significant in all the instances of cognitive processing. Newer research in the area of memory may lead to newer developments in the other areas of cognition. Now in the next section, we shall study the structure of long-term memory.

7.3 THE STRUCTURE OF LTM

Before we proceed with this section of this chapter, try to answer a few questions -

- Which is more round in shape - apple, mango or banana?
- What are the lyrics of your favorite song?
- How do you charge your mobile phone?
- When is India's Independence Day celebrated?
- What is 5 x 4 and what is 12 - 7?

To answer each question, you need to access LTM because all the information is being stored in there. Sometimes, you can recall quickly, at times, you may need some time. In whichever case, the storage of this information is LTM.

The differences between primary memory and secondary memory were made by William James in 1890. Long-term memory or secondary memory was described by him as a memory reservoir where information is absent from consciousness right now but can be recalled when needed.

We use STM when we call something to mind. But we have all our memories stored in LTM whether we currently think of those memories or not. Let us consider our LTM as the hard drive of a computer. Our LTM too has all types of files stored in like the hard drive of a computer - images, songs, text documents, etc. While using a computer, if you want to open a file right now, you use an application where the images will open in a photo viewer, text will open as word document, webpage will open in google chrome and so on. This application can be compared to short-term memory or working memory. So, the information is stored in LTM like a hard drive of the computer and the applications in the computer are like STM. When while walking on a road you see someone you know and call out their name or you recognize an actor in the movie or when you play a musical instrument that you have learnt -you are using information stored in your LTM.

7.4. MULTIPLE MEMORY SYSTEM MODEL

As discussed in the earlier chapter, STM and working memory have different independent components. But, LTM is presented as a single storage in a model proposed by Atkinson and Shiffrin (1968). However, this is not agreed by all and some researchers believe that LTM too consists of different components. The exact number of these components, nature of the components and relationship between them is not estimated and still debatable.

As a matter of fact, a systematic study on memory is documented in the book 'Über das Gedächtnis (On Memory)' which was authored by Hermann Ebbinghaus in 1885. His research focused on one particular aspect of memory. His studies were based on memory with respect to rote verbal learning. "Verbal learning involves learning and remembering language based items such as words and sentences (Gilhooly, et. al., 2014, p. 260). This type of learning also involves memorizing and recalling a list of words or stimuli based on some other language such as nonsense syllables. In his research, Ebbinghaus made use of trigrams like MIR, VOL, RAB, etc. which were nonsense pronounceable consonant-vowel-consonants to be learnt and remembered during the study. He himself was the only participant in the study. He memorized a long list of nonsense syllables, measured the time he took to memorize and the number of repetitions he needed to memorize till he could recall all the list correctly without any error. His finding shed light on nature of memory and forgetting, which will be studied in another chapter.

Many other subtypes of memory are addressed by researchers in this area. In a sarcasm essay, Tulving in 2007 made a list of types of memory which termed 256 memory types. The list also included gist memory, olfactory memory, intentional memory, flashbulb memory, non-conscious memory, generic memory and object-recognition memory. From this, one can see how big this task is and what skills one requires to make such a long list of types of memory. Roediger, March and Lee (2002, p. 1) recognized how a single term of memory involves multitude of human cognitive capacities. One of the easier ways to approach this long list and multitude of types of memory is by making groups of them based on whether they require conscious recollection or not (Gilhooly, et. al., 2014).

It is generally agreed by the researchers that non-declarative and declarative memory also known as implicit and explicit memory respectively differs from each other. Non-declarative or implicit memory is not accessed consciously or can it be report verbally. It is facilitated by previous experience without us being aware of that effect. Declarative or explicit memory involves conscious recollection of memories such as events, facts, people and places (Gilhooly, et. al., 2014, p. 261). Both these types of memory will be discussed in more detail in next sections of this chapter.

As rightly described by Ryle (1949); non-declarative memory answers ‘knowing how’ and declarative memory answers ‘knowing that’. Let us understand it with some examples.

Knowing that a vehicle called car has four wheels is declarative memory and how to drive a car is non-declarative memory. Another example of declarative memory is remembering the colour of your plate that you use for having lunch and non-declarative memory is the procedure of eating from the plate. Hence, ‘knowing that - knowing some information about something’ is declarative memory and ‘knowing how - knowing the use or purpose of something’ is non-declarative memory.

Conscious recollection of information stored inLTM involves declarative memory, whereas, recollection which is not conscious but instead is based on prior learning is non-declarative memory. You have prior learning of how to drive a car, you need not sit and recall the steps while doing so or you already know the purpose of a plate, you do not need to recall what should be used to serve food. You do not need to consciously think about the steps involved while driving or using a plate. (Graf & Schacter, 1985, 1987; Schacter, 1987).

Some memory tests depend on explicit (conscious) recollection of information, while others are measured by implicit memory. Methods like cued recall, free recall and recognition depend on declarative memory which is based on conscious recollection of information from the LTM. Examples of cued recall are ‘Name animal which has a long trunk and big ears?’ or ‘In which city is the Gateway of India which is surrounded by the Arabian sea?’. The recall is based on some hints. Then what is free recall? Examples of free recall are more directive in nature ‘What is the capital of Maharashtra?’ or ‘What is the color of an apple?’ Recognition method involves questions like ‘Is Kung Fu Panda your favorite movie?’ or ‘Is Kanyakumari the southernmost tip of India?’. All the above-mentioned methods (cued recall, free recall and recognition) make use of declarative memory and requires conscious recollection of information which is stored in your LTM.

However, other methods like word fragment completion and word association do not need conscious recollection. Word fragment completion method is a way to measure implicit i.e., non-declarative memory for a word which is already learnt previously and is stored in LTM. In this method, an incomplete word is presented which means, few letters of the word are presented and others are kept blank and one needs to complete the word. It is also called a word completion task. For example, E _ E _ _ A _ T (correct answer being ELEPHANT) _ I C _ O _ Y (VICTORY).

The other method of measuring implicit memory is the word association method. In this method, one is asked to study a list of words by making a story out of familiar locations or you make a peg framework of a shopping list that you want to remember. The first method is called ‘method of loci’. For example, a list of words would first be presented such as pen, bag, shirt, oil, etc. Next, one has to recall a series of locations on the way such as shops on the way from station to home. Then, one has to form an interactive image of first word and first location such as lost of pen being sold in first shop, etc. And so on. Weirder the image, better the memory. The other method is to use a peg system and make your own framework to remember something. For example, you can use rhyming words to remember a list of words like one - bun, two - shoe, three - tree, four - door and so on. In all the word association methods, you associate words with something which has some personal meaning to you.

Going back to the case study of the patient mentioned earlier in this chapter helps us understand the distinction between the non-declarative memory and declarative memory. The patient’s amnesia led to losing declarative memory, however, his non-declarative memory was not affected. He was able to learn new skills even after the onset of amnesia. However, he could not remember the medical staff names or faces who used to meet him on a regular basis. 147 cases of amnesia were studied by Spiers, et. al. (2001) in which it was seen that non-declarative memory was not affected and remained intact but difficulties with declarative memory was found.

Case study of a female patient having amnesia -

Swiss psychiatrist Edouard Claparede (1911) presented an informal narrative of a case of a woman patient who he was treating for amnesia. The woman was hospitalized for five years on account of amnesia. She did not recognize the doctors and nurses who treated her everyday. The patient would also forget information that was told to her in a minute and events that took place as well. A pin prick was decided to be used to convey an intense impression. So, he went to meet the woman and hid a pin in his palm which could prick her upon handshake. When he extended his hand for a handshake, she too greeted back and the pin pricked her but she seemed to have forgotten the prick quickly after that. After a few minutes, Claparede again extended his hand to greet her, but this time she refused to extend a handshake in spite of having no conscious recollection of the pain of the pin prick. When she was asked why she did not extend a handshake, she said that she has a full right to decide whether to greet someone or not and when asked about the reason behind the denial, she mentioned that maybe he had a pin in his hand. This shows that though she had no conscious recall of the event, she had some memory retained about the incident at some level which led to this behavior. Based on this Baddley (2004) proposed that learning in amnesia can extend to a variety of tasks which do not require explicit memory, that is retrieval of the original learning episode (Gilhooly, et. al., 2014, p. 262).

A three part model of LTM known as 'tri-partite' was suggested by Tulving in 1972. He made different distinctions within declarative memory, namely - episodic memory and semantic memory. Episodic memory is memory based on one's personal experiences, events and episodes, including autobiographical memory. Semantic memory is memory about the world's knowledge and facts, concepts and language.

Temporal context for recall is responsible for episodic memory, however, semantic memory does not rely on the temporal context for recall. Tulving provides an example of how remembering you saw a word is different from knowing meaning of that word (Gilhooly, et. al., p. 263). According to Tulving (1972) there are few key differences between episodic and semantic memory. Episodic memory is memory for situations, events and experiences, whereas, semantic memory is memory for language, facts and knowledge. Episodic memory is experiential in nature and is time dependent. Whereas, semantic memory is symbolic in nature and not time dependent. He also states that episodic memory is vulnerable to interference whereas semantic memory is less vulnerable to interference. 'When' and 'where' questions are mostly addressed by episodic memory and on the other hand, semantic memory addresses 'what' questions.

However, not all researchers in the field of memory agree that there is a good defined distinction between episodic and semantic memory. Cohen and Squire (1981) argued that not all types of memory strictly classify as episodic or semantic memory. For example, if someone asks you whether you are a good singer, your answer to this question will depend on - a) recall a memory about your recent performance (episodic memory), b) knowing how many years you are learning music and how many exams you have passed in this music (semantic memory) and c) combination of both the memory (autobiographical memory).

Squire (1986, 1993, 2004) suggested that LTM should be considered as differentiating between declarative (explicit) and non-declarative (implicit) memory; where declarative memory includes both episodic and semantic memory (Gilhooly, et. al., 2014). Squire (2004) also proposed that memory as a whole can be distinguished as declarative and non-declarative memory. Declarative memory is further categorized into facts and figures and the region of the brain which is associated with the same is medial temporal lobe diencephalon. Non-declarative memory is further classified into four parts namely; procedural memory (skills and habits) associated with striatum part of the brain, priming and perceptual learning associated with neocortex, non-associative learning associated with reflex pathways and simple classical conditioning of which emotional responses associated with amygdala and skeletal responses associated with cerebellum.

However, whether semantic and episodic memory involve separate or interactive storage is still debatable but evidence that supports the distinction between the declarative memory and non-declarative memory is much clearer.

In the next sections of this chapter, we shall study about non-declarative memory and declarative memory in much detail.

7.5 CONCLUSION

We have seen in this unit:

LTM in simple words means unlimited storage of information which is maintained and can also be retrieved for a long period of time, usually a lifetime. Capacity of LTM is infinite and cannot be measured in number.

In cognitive psychology and neuropsychology, the term 'amnesia' refers to a condition called 'amnesic syndrome' (Gilhooly, et. al., 2014). This condition impairs LTM functioning.

anterograde amnesia selectively affects LTM and has five principle characteristics (Cohen, 1997). Retrograde amnesia doesn't affect material that has been "over learned" before the onset like language, general knowledge, perceptuall, social and other skills.

7.6 QUESTIONS

1. Describe in detail about Memory And Amnesia.
2. Explain Multiple Memory System Model.
3. Write Short Note On The Followings:
   1. Capacity Of LTM
   2. Anterograde Amnesia
   3. Retrograde Amnesia
   4. The Structure Of LTM

7.7 REFERENCES

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8

LONG TERM MEMORY - II

Unit Structure

8.0 OBJECTIVE

After studying this unit students will be able to:

- Understand difference between declarative and non declarative memory
- Learn three types of non declarative memories
- Learn different types of declarative memories
- Understand important case studies in the field

8.1 NON-DECLARATIVE MEMORY

It is a general notion that whenever we think about recalling or remembering something, we have conscious recollection of an event or fact or experience. But, as a matter of fact, maximum use of memory takes place without our conscious awareness in our everyday lives. Lets understand this with an example. You don't need to make a conscious effort to recall that you need to bathe everyday. You know the process of how to switch on the fan or go and get groceries from the store. You know how to read this text. For all the above examples you do not need to recall anything consciously to perform these tasks. In all these actions memory plays an important role and you are not consciously aware of how it is guiding your actions. There is a wide range of tasks in our everyday life in which non-conscious memory is involved.

This non-conscious memory is known as non-declarative memory or implicit memory. As mentioned earlier, in this chapter, non-declarative memory is further classified and is exhibited in a wide range of our everyday tasks which is based on classical conditioning, skill learning and priming (Gilhoohly, et. al., 2014). Though there are few differences between these subcategories of non-declarative memory, they still collectively fall under non-declarative or implicit memory because they do not require conscious recollection. Unlike declarative memory, this type of memory (non-declarative/implicit memory) is found amongst all the animals and in evolutionary terms is the oldest of long-term memory systems (Tulving, 1985b; 1999).

Now let us study more about the subcategories of non-declarative memory i.e., skill learning, habit learning and repetitive priming.

8.1.1 Skill Learning

Skill learning leads to a subcategory of non-declarative memory known as ‘procedural memory’. Procedural memory is knowledge of skills such as driving a car, washing the dishes, using a computer, playing a musical instrument, writing your signature, playing any kind of game or sport and so on. Procedural memory includes using motor skills (physical action required to do something, e.g., sports, riding a bicycle), cognitive abilities (e.g., multiplying 4 x 7) and perceptual learning abilities (e.g., distinguishing between two shades of a color, recognizing two different odors). This type of learning is generally enhanced with practice over a period of time and can become automatic. In fact, sometimes, if we concentrate more on our thoughts than the actual skill, the skill can be disrupted and the performance can get affected. This effect is known as ‘paralysis by analysis’ in sports psychology (Moran, 2012).

Generally, procedural memory is not affected in patients suffering from amnesia. We have studied this already in the case study of the patient H.M. Another case study of an amnesia patient is of Clive Wearing, who was a musician. He suffered from profound anterograde amnesia along with extreme retrograde loss and his declarative memory was seriously impaired. However, his musical ability was not affected as much and he was still able to play the piano and read the musical notations but would avoid complex musical compositions, thereby indicating intact procedural memory (Sacks, 2007).

8.1.2 Habit Learning

Habit learning is based on the framework of classical conditioning. It refers to memory which is acquired through repeated associations between stimulus and responses. You may recall studying this kind of learning under behaviourism. This type of memory is researched vastly on animals through several types of experiments, however, the study of the same on human beings is not understood correctly as it is difficult to eliminate the influence of conscious recall (declarative/explicit memory) on learning material in case of humans (Bayley et al., 2005; Knowlton et al., 1994).

'Probabilities classification learning' is a type of task which is used to study habit learning without the interference of declarative memory. In these types of tasks, the participants are asked to learn a set of associations. The associations are not clear, hence making them difficult to memorize because of the unclear nature of the relationship between stimulus and response. The information obtained after many trials has to be used by the participant to complete the task successfully.

One such example of this study is by Squire and Zola (1996). The experiment had participants who were asked to complete a weather prediction task. Participants were presented with one , two or three cues (of the total four possible cues) on each trial and the task was to predict a weather outcome (sunshine or rain) . The cues included cards which featured triangles, squares, diamonds and circles. Each of the cues presented had unclear association with a weather outcome which had fixed probability. The associations were 75%, 57%, 43% or 25% respectively with each cue. When a trial had more than one cue, conjoint probabilities predicted the outcome. The participants could select their response by pressing a key which was followed by an immediate feedback about whether the response given by them was correct or incorrect. The participants were unable to rely on their memory from previous trials in order to learn the task, since the same configuration of the cue could lead to generation of different outcomes each time. This ensured that declarative memory was not affecting the task. Over a series of trials, participants' performance usually gets better from guessing (50%) to around 70% correct response. Patients having amnesia learn the task typically with the same rate as controls more or less, with similar response accuracy which is about 65% and after the training which is over a 50-trial block (Squire, 2008; Squire & Zola, 1996). However such patients find it difficult to recall factual information about the training received (Squire & Zola, 1996).

8.1.3 Repetition priming

Priming is an implicit memory effect, often facilitatory, in which exposure to a stimulus affects a subsequent response (Gilhooly, et. al., 2014, p. 267). Lets understand this with the help of an example. A study was conducted by Tulving (1982) to understand priming effect. The participants had to learn a few low frequency words like pendulum, theorem, toboggan, etc. Low frequency words mean words which are not commonly used in our everyday life. Each word was presented on a screen for 5 seconds, individually. Participants were informed that a memory task will be conducted on these words later. The participants were tested after an hour and again after a week. The participants were tested in two ways - recognition test (by yes, no questions) to check declarative memory and by fragment completion test to check non-declarative memory (both the types of the tests are already discussed earlier in this chapter in the section of 'Multiple Memory System Model').

The participants were given incomplete fragments of words in the fragment completion test with spaces that were to be filled by missing letters of the words. For example, T _ E _ _ E _ which stands for THEOREM and so on. They were asked to fill in the missing letters. Half of the words were from the list of words that were presented earlier and the other half were new words. The results showed that performance was better on those words which were seen earlier during the learning phase. In the recognition test where the participants had to simply say 'yes' or 'no' if they recognized those words that they had seen earlier. Interestingly it was observed that recognition was not well for fragments that had been correctly completed compared to those that were not identified. This supports the presumption that fragment completion requires non-declarative/implicit memory and not declarative/explicit memory.

In 1987 Squire conducted an experiment having a similar task in order to illustrate intact repetition priming without the interference of declarative memory in patients with amnesia. A task of word stem completion was given to the participants in this study. The participants had to learn a list of words. In the test phase of the study, the first part of the word - the stem was presented to the participants who had to then complete the word. For example - the word presented in the study list is 'capital'. Then in the testing phase, the stem 'cap___' would be presented to the participants. Now pay attention and see that there can be several possible responses to this stem - capital, captain, caption, etc. Squire had three test conditions in his experiment. First, in the free recall task in which the participants had to report as many words from the list as they could remember. In the second condition, a cued recall task, the participants were presented with stems and were expected to complete them by recalling words from the list presented and not any other word that would match the stem. In the third condition of the completion task, they were asked to only complete the stem – he made no mention of recalling words from the previous list that was presented earlier. It was observed that patients suffering from amnesia performed as well as controls on the fragment tasks. This supports the assumption that the task relies on non-declarative/implicit memory. However, patients having amnesia showed poor performance on the recall tasks which involve declarative memory compared to control participants.

8.2 DECLARATIVE MEMORY

This section of the chapter will explain in detail the subcategories of declarative/explicit memory namely; episodic memory, autobiographical memory and semantic memory as well as the studies conducted to understand each of the types. To begin with, let us study episodic memory.

8.2.1 Episodic memory

Episodic memory is the component of long-term memory which enables us to recall our past experiences. It allows us to re-experience past events consciously (Tulving, 1983, 2002b). Tulving (2002b) states three main characteristics of episodic memory.

First being that episodic memory is associated with our subjective sense of time and which enables us to engage in 'mental time travel'. In simple words, we can, in the mind i.e., mentally, 'travel back or go back or revisit' events or situations by remembering past events. Tulving argues that the phrase 'that takes me back' reflects the characteristic of episodic memory and is unique to only human beings. To experience this, try to recall your last birthday. The second characteristic of episodic memory is that the memory is connected to self. Self-reflection is a main feature to episodic memory. Tulving (2002) states that, "mental time travel requires a traveler". The third characteristic of episodic memory is that mental time travel is connected with a unique type of conscious awareness termed as autonoetic (self-knowing) consciousness. This type of consciousness facilitates thinking about ourselves in the future, and also to plan the future. It enables us to remember a past event and think how we could or may have done something differently. It is because of this memory that we can put ourselves in another person's shoes and wonder about what we would have done if we were in their place or to answer a hypothetical question such as " What will you do if you miss your train?", etc (Tulving, 2002)

Tulving (2002) puts forth that episodic memory develops late in maturation but has evolved recently in the history of human beings. It also deteriorates early and is vulnerable to disruption by brain damage. However, it is unique to humans and must have evolved from semantic memory. The loss of the episodic memory in amnesia is a devastating experience. This type of memory is constructive in nature (Gilhooly, et. al., 2014). When recall a past event, the memories are formed over again and can be different from the original event that had happened.

8.2.2 The reconstructive process of the memory

The term - 'mental time travel' (mentioned above) very aptly represents the experience of recalling or reminiscing. You all must have experienced how neatly defined or vivid memories of the past can be. But it is necessary to know and understand that episodic memory is not always an exact copy. It is not a replay of an event or situation the way it had occurred in the past as if watching television. Memory is constructive in nature and when we remember our past events, we reconstruct the event in our brain by using the information stored in our LTM before, after and during the event that took place.

Bartlett (1932) was one of the first researchers to challenge the idea that memory is built on 'unalterable traces', as proposed by Freud's description of memory (Freud, 1900; 1976). Bartlett pointed that memory is reconstructive and not just passive recall of records of events. He strongly debated that memory is not be thought of as something that can be literally reduplicated or reproduced. He considered it to be a matter of construction rather than simple reproduction (Bartlett, 1932).

This does not mean that recall always is definitely not accurate. It is just that it is not always an exact replication of past events. It can have modifications, changes and errors. Due to this reconstructive nature of memory, it is important to recognize the circumstances under which memory might be accurate and can be trusted and those situations when recollection may be inaccurate.

Bartlett's research focused on the importance of the schema in remembering the past experiences. He described the schema as "an active organization of past reactions, or of past experiences" (Bartlett, 1932, p. 201). According to him, "recall of memory involves condensation, elaboration and invention and all of these very often involve the mingling of materials belonging originally to different schemata" (p. 205).

Scehmas are memory structures that guide our behaviour by allowing is to connect our past memories to novel situations (Gilhooly, et. al., 2014, p. 271). They exhibit the relation between semantic and episodic memory. They produce expectations that decrease the lack of clarity of new events, but these expectations can sometimes lead to misjudgments. Brewer and Treyens (1981) found that depending on the situation, participants would report seeing items that they expect to see even if in reality the items were not presented. In a phenomenon known as boundary extension errors, people remember more of a visual scene than was originally presented(Brewer and Treyens, 1981, p. 208).

We tend to recall that information better which is consistent with our schemas, when facing a novel situation. At times we may also recall experiencing something purely out of our expectation instead of it actually happening in reality. A study was conducted by Brewer, W. F., & Treyens, J. C. (1981) to demonstrate this schema expectancy effect. They presented participants to a graduate students office. Now, the office was carefully designed in such a way that it had some typical items such as a typewriter, coffee maker, experiment tools whereas some unexpected items such as a skull and toy. The room was also missing some of the expected items like books and telephone. Participants were allowed to be in that room for 35 seconds after which in a surprise recall task the participants were asked to provide either a drawing or verbal recall of the items in the room. The participants reported a total of 88 items out of which seven were room frame objects(doorknob, light switch, etc) 62 objects were present in the room and 19 were inferred objects which were not present in the room. The inferred objects tended to be schema consistent items. 30% of participants in the study reported that there were books present in the office, but in reality there were none. As expected recall for the items that were indeed in room was better for items that were schema consistent.

In the verbal recognition condition of the experiment, the participants were presented with 131 object names out of which 61 of the named objects were present in the office and 70 weren't. The participants mistakenly identified 13 objects as being present that were not in the room, but were consistent with the schema of the office. In addition, salient items that is, easy to notice items were more likely to be recalled.

The Brewer and Treyens research is appreciated for its methodological soundness. It showed how information from schema gets combined with episodic memory. They also showed that if an item inconsistent with schema is unique/ salient, it is likely to be remembered. The research shows how correct recognition of objects, and wrong recall of unpresented objects could be predicted by schema consistency. More recent researchers have found effects of schema influence which are similar in nature during retrieval of eyewitness memories (Tuckey & Brewer, 2003).

Another research was carried out by Bartlett (1932) who was keen to know the process through which the participants could recall the events and also the influences of memory biases. The method used by him was as follows. He presented the participants with a narration of a story and then tested their recall by using a repeated reproduction method. The participants were asked to write down what they recalled of the story later. Their recollection of every detail of the narration was checked at different time intervals. He also used a serial reproduction technique, in which one participant needs to communicate the narration to the next participant and so on like done in children's game. One of the story presented was a North American Indian folklore titled 'The War of the Ghosts'. The story contains ideas or terms which are very different from the western culture.

When the participants recalled the story, they cut down the details at a considerable level, just by remembering the outline or idea of the story instead of the complete story. But it was found that they also made several changes to the details in their changed narration of the story. These changes which they added on their own is what Bartlett terms them as "transformation in the direction of the familiar" (p. 178). In many cases, participants made inferences that were possible in the story, however the information was not provided in the story. In such cases, the participants use information from schemas from their memory to adapt the story narrated in the study. The participants' confidence was quite high when recounting even inaccurate details.

Bartlette's experiment was criticized for lacking ecological validity. However, Bartlett's study was significant in indicating the reconstructive process of the memory, an inference which has been established several times since then.

Whenever one thinks of episodic memory, one naturally focuses on the past events, by remembering or recalling the past experiences. However, one cannot change the past events and therefore our cognitive system only focuses on past that helps thinking about future. This is an adaptive function of memory which allows us all to use past experiences of the events in order to adapt our behavior so we can deal more effectively with the present and future situations. You may remember a past exam in which you regret choosing a wrong answer to a particular question. It may have happened because you may have got overly apprehensive and this in turn affected your performance in the exam. Memory of past performance only serves to be useful if it is helping in improving future performance in some way. (Suddendorf & Corballis, 2008).

After studying the reconstructive process of memory, let us now study what prospective memory is and how it leads to imaging future events.

8.2.3 Prospective memory

Prospective memory is a memory that allows us to remember to perform certain tasks such as calling home at 8 PM, etc. (Winograd, 1988). It is also known as our ability “to remember to remember”

Tulving (2004) stated that a main task of the episodic memory is to allow us to ‘travel forward in time’ mentally. This allows us to use our memory for planning for the future. This means it allows us to have imagination of the future viz, to anticipate which career we might like or opt post completion of our studies, it allows us to make a vacation plan and also remember to buy eggs on the way back to home. This type of planning for the future is related to a type of memory called prospective memory. Prospective memory is memory for intentional actions. Those actions that are to be carried out sometime in future (Einstein et al., 2005). However, patients having amnesia are unable to have prospective memory, since they find it difficult to mentally visualize their future (Klein & Loftus, 2002). This kind of memory is used by us every day. For example, remembering to take a bath at a certain time, remembering to attend an event in the evening, etc.

The prospective memory failure involves failure to carry out an action at the scheduled time (Ellis & Cohen, 2008). For example, forgetting that we wanted to make a call to someone by 7 p.m. Lapses in prospective memory often involve not interrupting the habitual routines (e.g., going straight to office instead of going to bank atm to withdraw cash). Prospective memory lapses are different from action slips. They are errors within established or habitual routine activities. For example, forgetting to put your phone on silent before going to bed or eating with your hand instead of a spoon (Morris, 1992). Prospective memory is generally very effective. “March, Hicks and Landau (1998) found that in about 3% of the times, plans for coming week remain uncompleted because of forgetting to do them (Gilhooly, et. al., 2014, p. 278). It is observed that failure of prospective memory often results in embarrassment or even catastrophic moments.

Unlike other kinds of memory, prospective memory is not always triggered or cued by an external event that is obvious but instead the retrieval in prospective memory is self-initiated (Craik, 1986). This poses question ofwhat is it that allows recall to take place?(Morris, 1992, p. 202).

There are differences between event-based prospective memory tasks and time-based prospective memory tasks. Event-based memory are mostly triggered by acertain event related cue. For example, upon seeing my cousin Raj, it occurs to me that I have a msg to pass on to him, or passing by the refrigerator clicks to me to keep milk in it. These are examples of prospective memory that are event-based or event-cued (Graf & Grondin, 2008). When purpose is time-cued, a particular time brings about the action. For example, remembering to call your boss at 11 a.m. or remembering to check the cake in the oven in 45 minutes. Ellis (1988) proposed terms to these two different types of purposes - 'pulses' and 'steps'. What are pulses? Pulses are some purposes that must be done at some specific time (e.g., I must remember to call my sister at 9 p.m.) and steps are some purposes which have wider time frame (e.g., I must remember to go to bank sometime this week). Interestingly, Ellis found that pulses have better recall and also are more likely to be eased through memory aid, such as making a note in your calendar. This is because unlike steps, pulses have clear time lock.

8.2.4 An experimental study

Wilkins and Baddeley (1978) conducted research on pulses or time-based prospective memory using a pill-taking analogue. The participants were required to push a button at 8.30a.m., 1p.m., 5.30p.m. and 10p.m., for one week, and the device recorded the times at which the button was pressed. They found that 30% of participants forgot to push the button on at least one occasion during the week and they were unaware of this omission for as many as 36% of the errors. However, it never happened that a participant forgot that she had already pushed the button and repeated the action. Surprisingly, participants with poorer scores on a free recall task performed better on the time-based task.

The researchers do not want to propose that such results are found due to the processes of two different components within memory but, in each case the task requirements are quite distinct, and a fair comparison can be made only when the tasks are comparable. Hitch and Ferguson (1991) gave one such example. Participants were asked to recall films they actually watched and also films they wanted to watch. The memory for films already seen showed a recency effect, in that recall was better for those recently seen, retrieval of films to be seen in the future showed a proximity effect, with films to be seen sooner associated with better retrieval. Neuroscientific evidence also supports substantial overlap between brain areas engaged when thinking about the past and when imagining the future. Shared activity is evident in prefrontal cortex and medial temporal lobe regions, including the hippocampus and parahippocampal gyrus , as mentioned in Gilhooly, et. al. (2014, (p. 280).

Only in the past two decades has a systematic study of prospective memory begun in the field of cognitive psychology. In the history of memory research maximum research until then were focused on the past events and their recall on how and what was learned and then remembered. In recent times, research in prospective memory is emerging and has been interesting the researchers studying components of memory. Prospective memory deficits have also been linked to clinical conditions such as compulsive behaviors. This topic has been discussed in more detail in the following study.

The following research is conducted by Cuttler, C., & Graf, P. (2007) conducted a study on Sub-clinical compulsive checking behaviors. Compulsive checking behaviors are behaviors in which there are repetitive checking habits like - to check several times whether a door is locked, or is the microwave switched off. Repetitive habits are found in more than 50%

of patients having obsessive-compulsive disorder (OCD) and are seen at a sub-clinical level which means the behavior is found below the threshold for determining a clinical condition in around 15% of the normal population (Stein et al., 1997). One prominent theory of compulsive checking, the memory deficit theory, proposes that a deficit in prospective memory underlies the condition: the person knows, or believes, that they have a poor prospective memory and therefore thinks that they will make an error, this underlies the need to check than an intended action has been completed. This possibility of a link between memory and compulsive behaviors was explored in a study by Cutler and Graf (2007, p. 338).

They divided partcipants into high, low and medium checkers based on results of a self report inventory. They were presented with an event based prospective memory task and one time cued task. Results found that high checkers showed overall prospective memory failure especially on event cued task than compared to low checkers. There were also differences on the subjective measures of prospective memory, with high association between frequency of checking behaviour and reported failure of prospective memory. Thus they demonstrated role of prospective memory in explaining compulsive behaviors. However some studies have failed to replicate the results.

The next section of this chapter focuses on a subcategory of non-declarative/implicit memory called ‘autobiographical memory’. Now, let's study more about it in detail.

8.2.5 Autobiographical memory

Most events of our day-to-day life that happen are remembered only for a short period of time and they tend to disappear from our memory quickly. If I ask you what you had for breakfast today, you may easily be able to recall the information. However, If I ask you the same question next week, it is most likely that that information must have been lost from your memory. This happens with each one of us because this information is not unique in nature.

Conway (2009) stated that episodic memories set short-term goals and record the level to which they have been met. When particular episodic memories get fixed in the broader system of concepts and have interaction with semantic memories it leads to formation of autobiographical memories. These memories are for both personal episodic information and personal semantic information together. Personal episodic information includes personal experiences, right from day-to-day routine to lifetime experiences. For example, remembering your eighteenth birthday or remembering when you bought your first scooter (Brewer, 1996). Personal semantic information are facts about self, such as where were you born, or which school did you attend.

Autobiographical memory is associated with personal experiences (Linton, 1978) and also with the self (Conway, 1992). We can think about autobiographical memories as our life stories. It includes all the information that we can consciously recollect or recall with some detail and is time-marked as dating back to a specific period in our lives. Even though these memories are personal, they are not free from bias. Memory has a reconstructive nature, hence when we recall our life events of the past, our memory reconstructs or interprets the 'memory record' instead of just retrieving it passively.

Neisser (1981) proposed possible vulnerabilities of autobiographical memory which lead to bias and change. It happens many times that we are very confident about something and we believe that the event has taken place in a particular way in our lives. We narrate the event every time but if we ever wrote a diary and revisit that incident, we are surprised that there are different variations in our narrations though we were very confident while narrating the incident.

A research validation of such 'false memories' was given by Loftus (1993, 1997) through experimental investigation. The procedure in the experiment was designed to increase the likelihood that participants would report an unreal event as having occurred, in order to fix a false memory that was a little traumatic (Loftus, 1997, p. 71). She asked participants to recall 4 childhood instances that they were told were given by their close relatives (Research confederates). While 3 of them actually occurred, one was a false but plausible incident that never took place. It was observed that post presentation of the scenarios, participants recalled on an average of 68% of the true events. But almost one third participants reported remembering the false event, and one forth of participants continued to report recollection of the false event during two follow-up interviews. Studies have also found strengthening of false memories when repeated or imagined again and again, a phenomenon known as "Imagination inflation".

Hyman and Pentland in 1996 followed a similar procedure as Loftus and had participants examine true and false events. In one condition of the experiment, the participants were asked to imagine the event so as to make a memory of it. The false event in the experiment was an event in which the participant at the age of five was playing with other children at a wedding event and was knocked over by a fruit bowl on the parents of the bride. Those participants who imagined this scenario increased the likelihood of reporting false memories of the event. However, Hyman and Pentland mention that the demand characteristics may also have played a role. Demand characteristics are those parts of research that conveys to participants what expected result is, leading for them to behave in the expected manner, such as agreeing that a false event has happened.

This brings us to a phenomenon closely related to prospective memories called as Déjà vu, something that many of us have experienced. It is that eeri feeling that you have been to a place before even though you are visiting it for the very first time. It is a type of illusion of autobiographical memory which person knows that a situation could not have been described before, at the same time feeling that it has already occurred (Thompson et al., 2004, p. 906). It is generally used for visual experience.

Brown and Marsh (2010) put forth the possibility of three mechanisms in case of déjà vu. The first possibility is split perception. It means we get a brief mental vision of a scene, visual in nature before becoming aware of the real scene fully. The second mechanism is of implicit memory. In this it is likely that we have already experienced the event or part of the same but it has been stored in the memory in such a way that only a familiar feeling is evoked when we encounter it again. The third mechanism is related to the concept of gestalt theory, that the overall summation of the present scene resembles closely a situation that we have encountered in the past, though the events and specifications are different. So, we experience a sense of familiarity without being able to guess the exact reason behind the same.

Researchers have agreed upon few features of déjà vu (see Brown, 2003, 2004 a, b). They are follows -

- Most people experience déjà vu more than once in their lives and about two thirds will experience the same at some stage.
- The experience of déjà vu decreases with age and men and women experience it in equal frequency.
- It occurs more when people are under stress or tired.
- Relationship between déjà vu and both education and socioeconomic class has been found positive along with frequency of travel.
- Déjà vu does not last for more than 30 seconds and is related to a number of other experiences including déjà vecu (the feeling that one has lived through a moment before), jamais vu (when something familiar momentarily seems unfamiliar), and presque vu (the feeling that we are about to experience a moment of insight)" (Brown, 2004 a)
- It is usually reported for novel places or physical contexts, as well as with new people and in novel conversations (Kusumi, 2006).
- It is also seen in patients having pathological conditions.

Now we know that autobiographical memory is mainly based on our experiences in the past, and recalls and recollections of incidents of our lives. We also know that the information of facts about ourselves (our name, place of birth, the name of our apartment, etc.) is related to our semantic memory, and is a subcategory of declarative memory.

Let us now study in detail what semantic memory is.

8.2.6 Semantic memory

What is semantic memory? In simple words, "it is our store of general knowledge about the world around us, the people in it, as well as facts about ourselves. It includes our knowledge of facts, language, and concepts" (Gilhooly, et. al., p. 289). Semantic memory consists of all the knowledge we require for language usage. It is the organized information in our brain regarding words and other verbal symbols, their meaning and references about their interrelations and rules, formulas and algorithms, etc. (Tulving, 1972, p. 386). The knowledge and understanding we acquire at school, college and university along with words we learn at a young age and all the concepts known under the term 'general knowledge'; all taken together makes our semantic memory.

Even if two persons have the same experience, memories of both of them will differ from each other, since episodic memory is personal and there are considerable differences in the same from person to person. But this is not the case with semantic memory. For example, individuals who speak the same language and are from the same culture will have more or less common semantic memory. Let us understand this with the help of an example. We all have learned concepts and categories some time in life and if I ask you to describe a crow, you and I shall describe the same in similar ways like it is a bird, is black in colour, flies in the sky, etc. We both will describe a crow in a similar way.

Semantic memory is distinct from episodic memory in a few ways. For example, metamemory, which is our ability to draw inferences about our own memory differs for semantic and episodic memory and so do their neural correlates (e.g., Reggev et al., 2011). An example of metamemory is "Feeling-of-knowing judgement", which is estimate aboutknowing something we currently cannot recall (Gilhooly, et. al., 2014, p. 291).

One interesting finding of research in this area is, when people encounter some general knowledge information they do not know of, they generally accept it or choose unsure option. However,if they cannot remember an autobiographical event, they are likely to claim that the event did not occur (Hapmton, et. al., 2012, p. 348). Therefore confidence of eyewitnesses in reporting an incident as having or not having occurred is not a good enough indicator of its accuracy (Hampton, et. al., 2012, p. 350).

Studies in the area of amnesia show that semantic memory more or less remains unaffected and accessible even after a brain injury. We form concepts about the world and gain general knowledge and language in our early years of age which are used throughout our life. But what about the knowledge we acquire in school or colleges? Does it remain unaffected? Though there is a general belief that amnesia leads to loss of all the information stored in the memory, studies in this area show that there might be a phase of forgetting in the initial period, but retention period of knowledge is very long.

Bahrick (1984) studied memory for Spanish learned at school in a large samplewith up to a 50-year retention period. The sample included participants who were studying Spanish at different levels, those who had stopped taking its formal education and those who had never learned Spanish (baseline). Participants were assessed for recall, recognition and comprehension. The data showed an initial sharp decline in retention over a six-year period, following which the remaining memories became stable and there was no further loss of knowledge until up to 25 years later, with some amount of forgetting beyond 30 years. In a similar study involving recall and recognition of names and faces of school yearbook, Bahrick et al. (1975) found that Visual memory was retained for at least 35 years while verbal memory was found to decline after 15 years.

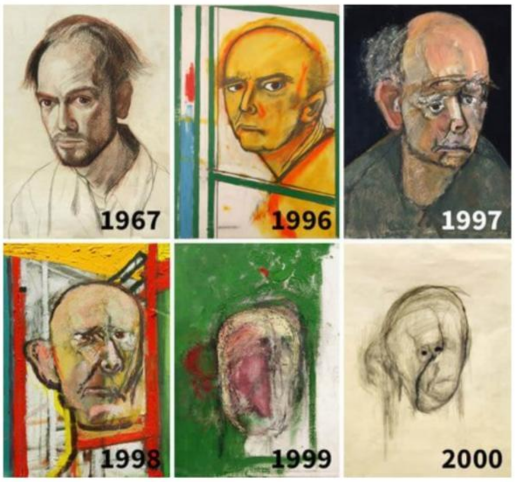
8.3 CONCLUSION

Thus, there are differences between non declarative/implicit and declarative/explicit and memory. However, it is important to acknowledge that there is significant interaction between different memory systems which often are bound together in our everyday experiences. With respect to Squire's (2009) example, a frightening childhood event, such as being trapped in an elevator, could lead to a long-lasting conscious recall of the memory of this event, but it may also lead to the person developing a fear of elevators, implicitly.

The relationship between non-declarative and declarative memory goes even further. Few neuro psychologists and cognitive psychologists argue that there is some kind of procedural memory's involvement in many tests of declarative/episodic memory (Kolers & Roediger, 1984). In a similar way, research studying memory consolidation have indicated that declarative and procedural memory processing do interact with each other (e.g., Brown & Robertson, 2007). Further research is needed to explore the same.

Now, it must be clear to you what are the differences between declarative and non-declarative memory also within declarative memory's subcategories; between episodic and semantic memory. But the degree of overlap or distinction between all the processes still needs to be explored more. It may also be true that all the processes may be functional in a continuum or in interaction with each other needs to be studied. Example of the same is autobiographical memory which is partial episodic memory and partial semantic memory for the self. It shows us how the two systems overlap each other. The research in personal semantic memory; which is a part of autobiographical memory, is only at the initial area which needs to be explored in depth. Personal semantics is largely personal and can vary from individual to individual, however, it is not episodic memory and is not linked to any specific episode that can be recalled. Its nature is a combination of episodic memory and semantic memory. As Renoult et al. (2012) outs forth studying episodic and semantic memories in isolation is a major under appreciation of actual functioning these systems. Lastly, while summing up this chapter, it is important to know that it looks like the current models of declarative memory needs future research more in depth before one can really understand, describe, predict and realise capacity of episodic memory and semantic memory.

Interesting trivia



Picture credit - boredpanda.com

The above image is a series of self-portraits made by American artist William Utermohlen. He was diagnosed with Alzheimer's in 1995 which, a disease which is associated with memory impairment. He created his portraits in the mentioned years. He used to paint without looking in the mirror, based only on his memory. We can see clearly that post 1995, he could barely recall his own face and his paintings depict a decline in his memory.

8.4 QUESTIONS

- What are the subcategories of declarative and non-declarative memory? Explain each subcategory in brief.
- How do semantic memories differ from episodic memories?
- What is amnesia and explain the two types of amnesia?
- What is prospective memory? Explain in detail.
- Describe reconstructive nature of memory in detail.

8.5 REFERENCES

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