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| Principal Investigator | Co-Principal Investigator | Co- Principal Investigator |
|---|---|---|
| **Prof N.K.Chadha**<br>Head and Professor,<br>Department of Psychology,<br>University of Delhi | **Dr Jaswinder Singh**(Principal) and<br>**Dr.H.V.Jhamb** ( Associate Professor)<br>SGTB Khalsa College<br>University of Delhi | **Dr Vimal Rarh**<br>Deputy Director Centre for e learning<br>Assistant Professor, Department of Chemistry,<br>SGTB Khalsa College, University of Delhi |
| **Paper Coordinator** | **Author** | **Reviewer** |
| **Dr. Pooja Wadhawan**<br>Assistant Proffesor<br>Department of psychology<br>Mata Sundari College<br>University of Delhi | **Dr. Pooja Wadhawan**<br>Assistant Professor<br>Department of psychology<br>Mata Sundari College<br>University of Delhi | **Dr. Soumi Awasthy**<br>Sceintist F<br>DIPR,DRDO,Delhi |
| Anchor Institute : SGTB Khalsa College, University of Delhi | | |


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## 1. Learning Outcomes

After studying this module, you shall be able to

- Understanding the concept of memory.
- Explain the three store model of memory.
- Describe sensory memory with its two kids: Iconic and Echoic memory
- Discuss short term memory as a working memory
- Describe neurocognition and short term memory.

## 2. Introduction

Memory holds a very important position in the work of cognitive psychology. It is this topic which has been thoroughly investigated and worked upon by many investigators: William James and Hermann Ebbingaus. Interest in memory captivated the attention of experimental psychologists, who further elaborated the theories of mental representations of how the information can be stored. This is very much evident in humans, as the lives of humans have meaning only if they remember what all has happened. Imagine if we were not able to recollect important events of our past, which we are, where were we born, what we had done in school and even what you had done just few minutes ago. Therefore the loss of memory would result in stealing of one's very life and person hood.
This chapter focus on the three store model of memory, which emphasizes that memory, can be divided into three types which are sensory memory, short-term memory and long-term memory. We will focus on first two forms of memory, which are sensory and short term memory. Long term memory is discussed in the latter module. Diagrammatical representation as follows:

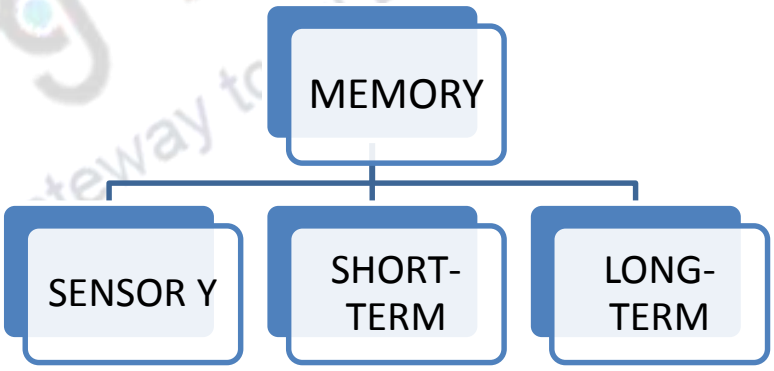


Figure shows the three store model of memory

## 3. SENSORY MEMORY

It is the first step of memory, at this stage the information enters the nervous system-eyes, ears, and so on. Information is encoded into sensory memory as neural messages in the nervous system. As long as those neural messages are travelling through the system, it can be said that people have a memory for that information that can be assessed if needed. Thus sensory "memory" is closely connected to what we call as "perception". Baddeley (1990) has described it as a record of our own precepts, as it is related to a brief storage of sensory information. Sensory memory refers to the brief persistence of stimuli following transduction. For example, you are in a party and talking to someone but suddenly

you look back to check on what that person who just passed by you was wearing. The question is that how did you know that you need to look back. Your eyes had already moved past the possible wearied looking guy in almost shorts in a party. This happened because some part of your brain must have processed what you saw. This is called double task and can only be explained in the presence, however brief, of a memory for what you saw. The major function of it is to perceive recognize and further enter into short-term memory. Sensory memory plays a very important role in our memory, if sensory memory would not have been present then the environmental events could not be remembered as soon as they get registered in the nervous system.

There are two kinds of sensory memory that have been studies extensively. The first one is Iconic memory, associated with sight and the second is Echoic related to hearing.

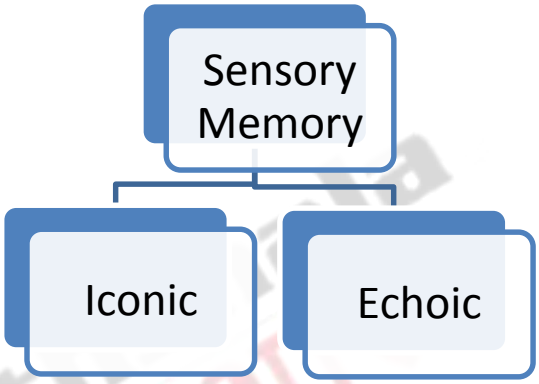


Figure shows two types of sensory memory

## 3.1 ICONIC MEMORY

It is a visual memory that lasts only for a fraction of second. In vision, the brief persistence of sensory memory is called iconic memory. The classic work on iconic memory was first investigated by Sperling (1960). Let us take another example to understand the concept more clearly. Suppose you need to remember a new telephone number of your friend's, for doing this our brain can use a variety of strategies. The brain may visualize the numbers which are supposed to be remembered by us. This process of visualizing in an imagery form is called iconic memory.

**Capacity of iconic memory:** Sperling's work indicated that it has a huge capacity – in which information can be stored greater than what can be reported at once. In his study he presented a set of nine letters for only 50 milliseconds to his observers, by using a device called tachistoscope. The observers were without delay asked to recall as many letters as possible. His participants could report four/five letters. Sperling called this situation the "whole report condition". As the letters were located in their shapes, spaces and also when the names were recognized, some of the letters seemed to be lost. He assumed that this happened because visual information had faded before most of it could be reported, as all the letters persisted briefly in iconic storage. It was observed that the letters stayed very briefly in our iconic memory. On the other hand if the information is verbally reported the letters required more conscious effort to recognize and represent in short-term memory. However they claimed to have seen many more letters. Sperling's findings supported his assumption, and indicated that information in iconic storage decays within about 0.5 seconds.

To further investigate the accuracy of this method he further developed "partial report method". In this method the subject had to ret call only the letters present in one row but they were not aware from

which row. But immediately after the presentation a high pitched tone occurred to indicate top row letters are to be reported. Again when medium pitched tone occurred to indicate middle row letters and low pitched tone occurred to indicate the bottom row. Using this method, Sperling found that subjects could accurately report any of the three rows. This means that the entire three rows was in iconic memory and available to the participants. Therefore the capacity of iconic memory is all that can be seen at one time.

**Function of iconic memory**: it plays a very important function in our visual system. Iconic memory is important for our visual system as it helps to view the surroundings as continuous and stable in spite of the objects movements, which keep vision from adapting to a constant visual stimulus. It therefore provides enough time to the brain stem to decide if the information is important enough to be brought into conscious level or not.

## 3.2 ECHOIC MEMORY

Echoic memory is referred as a brief memory of something a person has heard. It is an auditory system that can store sensations that are relatively unprocessed input. For example, suppose someone is reading an interesting book is asked a question. The first reaction of the person would be what have you said? This phenomenon states a very good example of echoic memory. Here the person has not really processed the statement from the other person, which eventually leads to this phenomenon of what. The person has heard it but the problem arises in interpretation of the statement. Later on the person will realize what has been said to her. This "playback" facility depends on the echoic memory.

The playback facility as discussed above may be used by repeating the numbers or letters loudly which we intend to remember. This will help us in focusing our attention to specific task which we are intending to remember for later on.

Echoic memory's capacity is limited as it can store information heard at one moment and its capacity is smaller than of iconic memory, it can last much longer for about 2 to 4 seconds (Schweickert, 1993).

Echoic memory is very useful when a person wants to have meaningful conversations with others. It allows the person to interpret and remember what someone has said so that they can respond further to the phrase said by the other person. If it is to be compared with iconic memory, there the incoming auditory information stays for that long where the brain can decide if the incoming information is useful or not to become conscious.

## 4. SHORT TERM MEMORY

Short-term memory, also referred as primary or active memory, in this all the information which we are currently aware of or thinking about are stored. Information which has been received from the sensory memory enters the next stage of memory, called the short-term memory (STM). The process takes place through selective attention; it is the ability to focus on only one stimulus from among all sensory input (Broadbent, 1958). For example, suppose you need to dial a number from a directory, you silently rehearse that number till you reach your telephone. If a delay happens in dialling that number it will be easily lost from our memory, which seems to be available temporarily in a short term store. Short-term memory is there for a brief period of time and especially that information which had been there at that moment, which is the part of our conscious experience. Itcannot hold much information at one time thus referred as 'smallest' part of memory. Its size can be estimated by

measuring memory span (or span of attention or span of apprehension). Chunks are formed to remember the items in a much better manner.

Short term memory is also referred as working memory. This term emphasizes the fact that the short term memory is not merely a "box" into which information is placed but is a working, active system that processes the information at any given moment. Therefore it helps in maintaining the mental representations that are relevant to the performance of the cognitive task in an activated state. It has been proposed that short term memory consist of three interrelated systems within it. The central executive is also called the "big boss" that controls and coordinates the other two systems. The other two systems are the visual sketchpad and auditory system as a recorder (Baddeley, 1986). The central executive function is to act as an interpreter for both the visual and auditory information in STM. For example, when a person is reading a book, the sketchpad will contain images of the people and events of the particular passage being read while the recorder "plays" the dialogue in the person's head. The central executive helps interpret the information from both systems and pulls it all together. The following figure shows the hierarchy of a memory system or the components of memory.

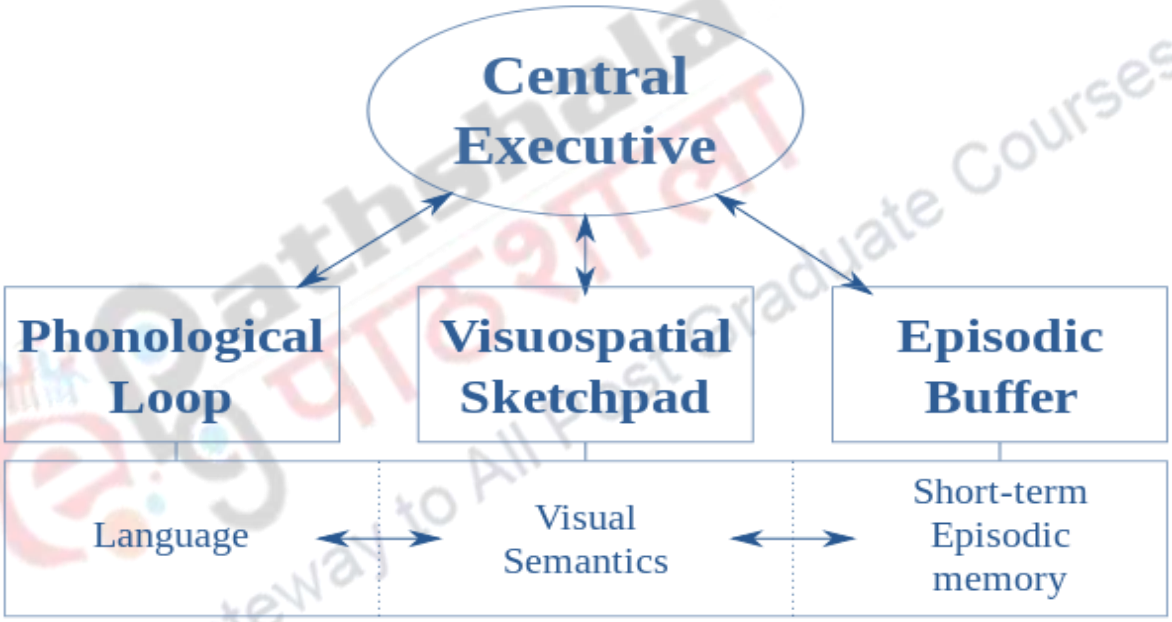


Figure shows the hierarchy of a memory system

According to the model given above, working memory has several components (Baddeley, 2002). One of the components is the phonological loop that can briefly store all the mental representations related to sounds. The phonological loop is active when we listen to a spoken word, or when we repeat some word to ourselves and even when we read a text in some form of language.

The second component refers to the visual sketchpad that can briefly stores the visual and spatial information. This takes place when an image or when we form a mental image of someone's face or a spatial layout of our room in our house. Both the two components can work simultaneously. For example, you can silently repeat the word sunrise while at the same time holding mental image of a sunrise or that of birds chirping.

The third component of the memory system is the episodic buffer that has a temporary storage space. In this stage the information received from the long term memory, phonological loop and visual

sketchpad are included, manipulated, and further made available for conscious processes (Baddeley, 2002). For example, your teacher ask you "how much is 23 plus 86?" you may maintain the autistic codes as you hear the question by using the first component of memory, phonological loop. Your visual sketchpad will help you maintain a mental image of the numbers. But if you want to successfully complete the task, the rules for performing addition must be retrieved from your long-term memory. This creates the ingredients for the conscious perceptions that you may experience as you perform the mental addition (e.g. 3+6 = 9 and so on.....).

The term working memory focus on all those systems that can accomplish any cognitive task. The span of working memory can be measured by referring to a dual-task situation that demands attention to be focused by the subject upon it rather than just remembering a list of words. Let us understand with the help of an example in which a reading span test was performed on the participants. They were asked to read and understand a series of sentences and were also asked to remember the last word of each sentence (Daneman & Carpenter, 1980). During this test, the participants had to do a series of mathematical questions and they were also supposed to remember words paired with each question (Engle, cantor, & Carullo, 1992). These tests of working memory required active processing of all those tasks that are relevant to be stored in our short term storage. Both the test requires coordination of two tasks thus they require central executive attention. Individuals with a larger capacity of executive attention attain higher span score, as do those with greater short-term storage capacity.

## 4.1. CAPACITY OF SHORT TERM MEMORY

The amount of information stored in STM is small compared with the vast amount stored in LTM. The capacity of short term memory is often referred as memory span. To assess the memory span of a subject, the experimenter presents lists of items that might consist of numbers or words in an increasing length. To determine the span of an individual we have to observe the longest list length that he or she can recall correctly in the given order.

Psychologist George Miller after his research had recommended that human short-term memory has a forward memory span with approximately a limit of seven items plus or minus two in it. Recent researches showed that memory span can vary with the population in focus and even with the material being used. This clearly lead to the conclusion of "magical number seven" which was nearly accurate for college students where they had to recall a list of digits. This can be understood with an example, the ability to recall words in order depends on a number of characteristics it holds: fewer words can be recalled when the words have longer spoken duration; this is known as the *word-length effect*, or when sound of their speech are similar to each other; it is called the *phonological similarity effect*. The number of words recalled increases when the words are highly known or occur frequently in the language. Recall performance also seems to improve when all of the words in a list belong to a single semantic category rather than when the words are taken from same categories.

As the evidence suggest, four pieces is the best overall estimate of the short term memory or when the information is broken down into "chunks".

**Digit span test:** Subjects in the experiment were asked to recall the digits in serial order. Each series gets longer and longer, until the subjects cannot recall any of the numbers in order (as shown in figure below).

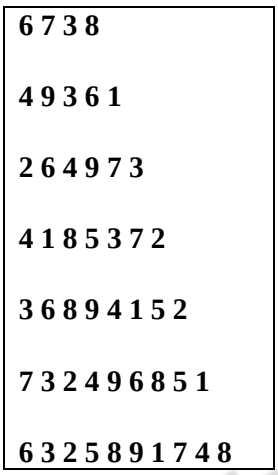


Figure shows how digits span numbers are presented

## Chunking

Chunking is the process of expanding one's ability to remember things for a short period of time. Chunking is also a process by which people can organize their material into meaningful cluster. If the information is broken down into bits so that meaningful units, or chunks are formed which makes it possible to hold on more information in STM. Even though the normal person may retain only about four units of information in the short-term memory, but chunking makes it possible to increase a person's recall capacity. For example, in the process of recalling a phone number, the person could chunk the digits into three groups: first, the locale code (such as 123), then a three-digit chunk maybe ones house number (456), and, last, a four-digit chunk which could be your car number (7890). This method of remembering phone numbers by dividing into chunks is more effective than trying to remember a string of 10 digits. This process of recording, or reorganizing, the information is called chunking. Practice and the systematically using the existing information in long-term memory can lead to additional improvements in one's ability to use chunking.

## 4. 2 LOSS OF SHORT TERM MEMORY CONTENTS

**Rehearsal** is the process by which we mentally repeat the information to keep it in the short term memory. During the process of repetition every time, the same information is re-entered into the short-term memory, where it lasts for another 15 to 20 seconds which is the average storage time for short-term memory. It is through practice when one repeats the information to be remembered over and over in one's head in order to maintain it in short-term memory. It is a process of paying attention to the information, which is to be held in our memory system. Since attention is the key for storing all in the information in STM. With rehearsal, information will be stored in STM and the role of rehearsal will stop.

**Decay of information** will happen when rehearsal stops, the memory rapidly decays and forgetting will take place. Decay occurs when memories fade over time. This does NOT apply to Long Term Memory, but only applies for sensory storage and Short Term Memory. The main reason this occurs in sensory and/or short term memory is that we don't need to process and store all the information that

we encounter in the world, so we simply don't attend to, recognize, or rehearse all the information, and this information just fades away not to be stored in our long term memories.

**Interference of similar information:** If any information interferes during the rehearsal, memories are also likely to be lost. For example, if someone is trying to count a stack of money by reciting each number out loud while counting and someone else asks that person the time and interferers with the counting process, the person who is counting will probably forget what the last number was and have to start all over again. Short-term memory helps people keep track of things like counting.

**Intrusion of new information into STM:** interference in STM can also happen if the amount of information to be held in STM exceeds its capacity. Information which is already stored in STM would be "pushed out" so that new information can be placed in the memory system.

## 5.NEUROCOGNITION AND SHORT TERM MEMORY

Neurophysiologic findings suggest that a separate memory store could be located structurally with the human brain. The most famous case was presented by Brenda Miller (1996), focused on physical trauma and brain lesion. The patient complained of severe epilepsy, and surgical excision was done of the medial temporal region to relive him of the symptoms. The procedure removed parts of the temporal lobe, including the hippocampus. It was observed that his epilepsy was improved, but became profoundly amnesic and could not store new information in LTM. He could recall a series of numbers momentarily presented, as STM was unimpaired, but could not retain similar information over long periods of time. Because the lesions took place in temporal lobe and hippocampus, it is apparent that these sites contain import ant memory structures. He made a startling discovery that temporal lobe lesions can learn implicit types of tasks that involve perceptual and motor skills. Furthermore these patients can retain the memory of these tasks for long periods of time.

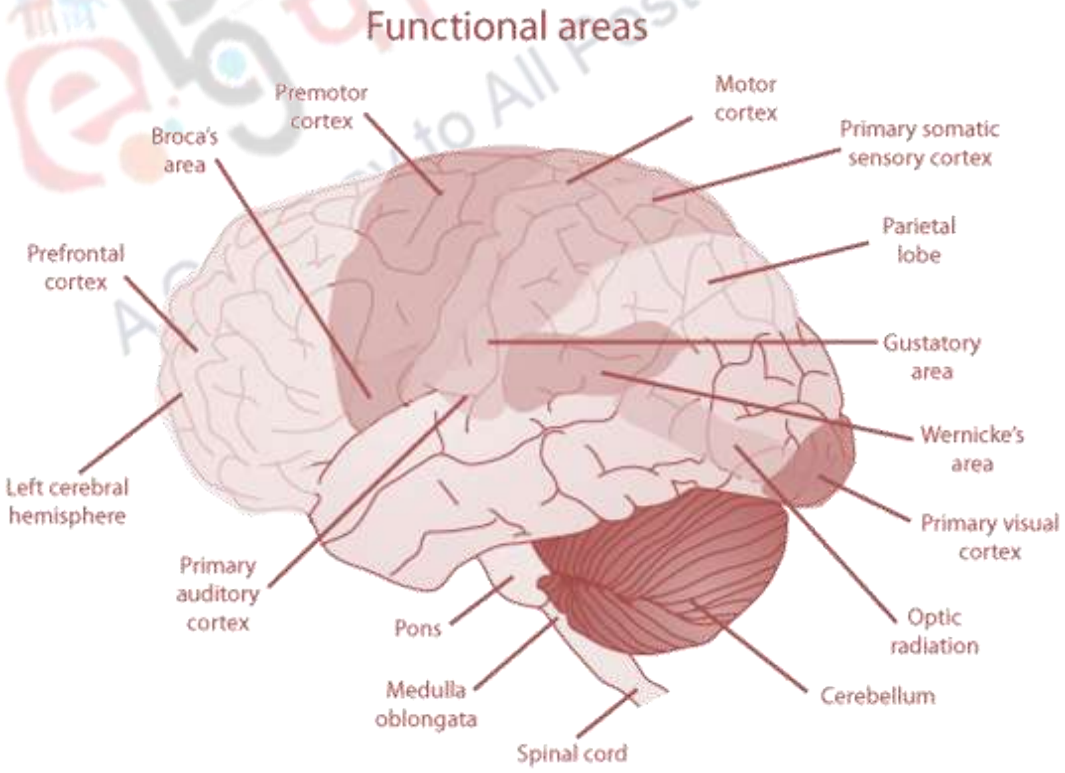


Figure above shows the different subcortical areas of the brain.

To explain short-term memory its best example would be of a chess master who can think of several possible solutions mentally before choosing the right move that will lead him in the game to checkmate. It is the ability in humans to hold on to a piece of information temporarily in order to complete a task. It causes the pre-frontal lobe to be at an active state. This region is present at the front of the brain, and is highly developed in humans. Hence, the part of the brain that seems to be mostly active during one of the most human of activities is located precisely in this prefrontal region that is well developed only in human beings.

Findings from other brain-damaged people have implicated areas in the frontal lobe as having much to do with the working memory. Thus damage to the frontal lobe was associated with disrupt attention, planning, and problem solving, as they are the important components of the central executive in the working memory.

Baddeley's model also explains the existence of a **phonological memory related to** acoustic and linguistic memory and a **visual/spatial** memory related to all mental images. Brain imaging studies have also revealed distinct neuroanatomical bases for both of these forms of memory. The phonological loop activates certain areas in the left hemisphere that are associated with the production of language, such as Wernicke's area and Broca's area. Visual/spatial memory seems to be associated with a region of the occipital cortex generally associated with visual processing

## 6. SUMMARY

- Memory has been regarded by many cognitive psychologists as the most basic cognitive process. Thus it helps us in thinking, remembering our personal events.

- The three-store model has fueled important improvements in our understanding of human memory. In spite of different problems which are being faced by this model, its core assertion sensory and short-term memory can be differentiated in terms of their capacity, storage and duration till it lasts and accounts for an impressive evidence in research area (Estes 19888; Healy & McNamara, 1996).

- Sensory memory was further divided into iconic and echoic memory. The process of visualizing in an imagery form is called iconic memory. Auditory sensory memory is called echoic memory; its duration is brief, but aural stimuli such as speech are also stored for longer periods of time in short-term memory.

- Short-term memory (STM) or "working memory"-holds information we are actively thinking about; limited in capacity (~ 7 items) & duration (less than a minute unless actively rehearsing). The short-term memory capacity is limited to about four chunks of information. The duration is less than 30 seconds.

- Working memory is the system for temporarily maintaining mental representations that are relevant to the performance of a cognitive task in an activated or conscious state.

- Baddeley's model explains that verbal information are stored in our phonological loop; nonverbal information in the form of a visual-spatial sketch pad; and integrated event representations, called the episodic buffer. Processing in these short term stores is controlled by the central executive.

- Neurocognition In the above discussion it was identified the role of hippocampus as a part of the brain that is responsible for the formation of new long-term memories. Research involving

PET scanning techniques strongly suggest that short-term memory are stored in the prefrontal cortex, which is very front of frontal lobe and the temporal lobe (Goldman-Rakic, 1998).