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IMPLICATIONS FROM HUMAN MEMORY PROCESS TO ENHANCE L2 VOCABULARY

PEDDIPAGA RAMABABU,
Ph.D. Scholar
Dept of English,
MANUU, Hyderabad,
(TELANGANA) **INDIA**

ABSTRACT

This paper displayed the criticality and complexity of human memory in the realm of learning with the help of information processing model, which shows the processing of the data from sensory memory to long-term memory, through working memory along with the valuable inputs to be focused at each level. It amplified the research studies of neuroscience to appeal the learning and teaching communities across the world to realize the criticality of human memory process and it urges to design their own strategies either to learn or teach L2 vocabulary in ESLL contexts after understanding its complexity.

Key Words: *Brain, memory, neuroplasticity, long-term potentiation, consolidation, vocabulary.*

INTRODUCTION

English as an international language promotes academic, social, cultural, economical, and political relations among the nations of the world. Learning or teaching English as a foreign language or second language is the common phenomenon in many parts of the world. Though English language is the composition of many language items, vocabulary is an undeniable item for quick learning of LSRW skills in English language. Vocabulary development is one of the most important aspects of students' life. It affects their thoughts, actions, aspiration, and success, particularly in academic field. In the fast growing world, every branch of study demands good amount of vocabulary for all round development. We have several approaches and methods in English language teaching to be used to enhance L2 vocabulary learning, but none of them focused on the role of human memory process though the brain is organ of learning.

According to Wolfe (2010), human memory is invisible and intangible but it is a process. It was understood with the help of two major metaphors: One is that it is an intellectual muscle, which becomes stronger, the more we use, another is from the writings of Plato that it is a tablet of wax, which impressions remain stronger on, the more we rehearse the experience. It is essential to our survival but complex to define.

Daniel Siehgel (2000), psychiatrist who rephrased Hebb's law as "Neurons that fire together, survive together, and wire together" explained the complexity of human memory system. When a person asked another to picture Eiffel Tower in his "mind's eye," the sound waves reach tympanic membrane in the ears and sent to Corte which turns them into electrical impulses and directs to temporal lobes which further sent the information to occipital lobe for visual processing. Then the person sees Eiffel Tower in his mind. In this phenomenon, neural networks that were formed earlier would be reactivated to see the picture in mind. Surprisingly, this mind picture brings back the events associated with it, when the person actually visited Eiffel Tower. Begley (2008) summarized that while recalling a visual image, the person activates many of the neural networks that associate with the picture.

Information-Processing Model

Wolfe (2010) explained the human memory system from the perspective of Information-processing model based on technology and updated understanding from various fields like neuroscience, cognitive psychology, and developmental psychology. The following diagram shows functional properties of human memory system. The division is neither to believe that those categories have places in brain nor autonomous systems in the brain but they are only useful to understand the process how the human brain receives, encodes, stores, and retrieves information:

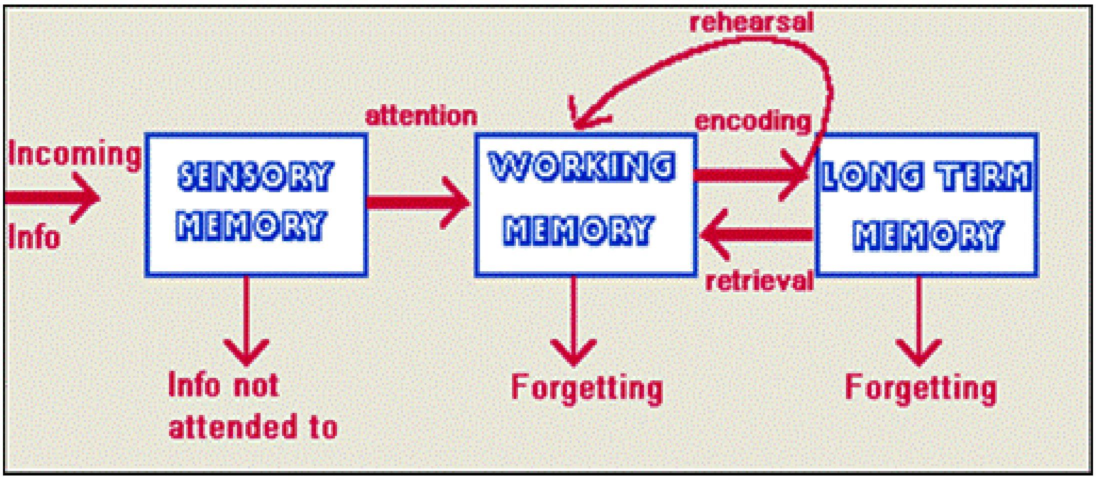

Image: 2.1. Retrieved from: http://aaboori.mshdiau.ac.ir/FavouriteSubjects/human_memory.htm

The image shows the information-processing model of the human brain. The sensory memory allows that data from all the senses, process it in working memory, and sends the data to long-term memory. Whenever brain attends familiar stimuli through the process of recoding or rehearsal, it draws related data from long-term memory into working memory, which consolidate previous data with new data and sends into long-term memory again. Discarding the unattended and irrelevant data is the common procedure at every level.

Sensory Memory

Gazzaniga, Ivry, and Mangun (1998) showed that the memory process of human beings is initiated when the data strikes the senses. Information that is received from the senses will be held for a fraction of second until decision is made what to do with the information. The exception to the sensory stimuli is the auditory stimulus, which is briefly recorded in echoic memory and lasts approximately within 20 seconds. Gazzaniga (1998) further explained that the sensory input is a continuous process. It showers the enormous data, which is unmanageable at a time. So sensory memory filters enormous data and discards irrelevant data. There is another metaphor about brain that it might be rather a sieve than a sponge. According to some estimation, 99% of data will be discarded immediately after entering the brain. For instance, a light ray hits retina of the eye and creates memory (iconic memory) which lasts in milliseconds. There are auditory stimuli that are recorded briefly referred to echoic memory. Gazzaniga, Ivry and Mangun (1998) studied that the echoic memories last a little longer. It might be as long as 20 seconds. The sensory input does not arrive as one piece of information at a time but enormous amount of sensory stimuli, which is unmanageable to comprehend everything. Therefore, the sensory memory filters the enormous data and discards irrelevant data.

According to Wolfe (2010), all the selected sensory data except information of smell, reach sensory cortex to be relayed through thalamus to evaluate content. Then, it will be sent to appropriate cortex to process the data of sight, sound, taste, or touch, whereas Information of smell will be processed simultaneously by olfactory bulb. Next, information will be transformed into photon of light or sound wave into percept. Perception refers to meaning that is associated with information. The received information will be influenced by the stored data in the memory, for example, if somebody is asked what the number is, showing 'β', we may say thirteen, and if somebody is asked, what the letter is, he or she may say /bi/. For young children who have not learnt either numbers or letters it is meaningless. Therefore, the previous knowledge is the determining factor of the meaning for present stimuli. Neural networks often search for matching in incoming stimuli. This process is called "pattern recognition".

Gabrieli and Preston (2003) conducted fMRI research to track the parts of the brain and levels of their activation in processing visual memory while the subjects were engaged in review of a series of pictures. It was found that the levels of activity in prefrontal cortex and specific areas of the hippocampus correlated with how well the particular visual experience was encoded and remembered. Wolfe (2010) stated that when a thing is given to learning, the brain focuses on different properties of the thing such as shape, color, length, taste, and movement and it processes each property by activating concerned neural networks with updation. Gray, Gray, Braver and Raichle (2002) studied that the negative emotions and fear activate amygdala, which shuts other parts of the brain and make hard to learn, since emotion and cognition are integrated in the lateral prefrontal cortex.

Attention

Robert Sylwester (1995) studied that the emotion drives attention and attention drives learning. Colombo et al. (2004) studied that certain amount of essential fatty acids, a child received from its mother's body or breast-feeding facilitated the attention span. They were more engaged with complicated toys and less distractible during the play. This immersion theory was related to Csikszentmihalyi's "flow" theory (1990) which was defined as a state of satisfaction while one is absorbed by an activity. The levels of attention and concentration of video game players on the goal to obtain rewards increase progressively ((Hubbard, 1991) cited in OECD-CERI 2003a). Noble, Tottenham and Casey (2005) cited the work of Mezzacappa (2004) which showed the outperformance of subjects from higher socio-economic status (SES) with regard to cognitive control such as the ability to ignore distraction, allocate attention, and hold items in working memory. Noble, Norman, and Farah (2005) examined neurocognitive functioning of Afro- American kindergarteners from different SES using cognitive neuroscience tasks and it was found that SES of the subjects correlated with the performance on the test battery as whole. Wolfe (2010) stated that the brain's basic functions are scanning its environment, filtering incoming stimuli, care for meaningful stimuli, and discard irrelevant stimuli.

Long-Term Potentiation (LTP)

Squire and Kandel (2000) demonstrated this theory with an animal. Most of the neuroscientists accepted that this might be one of the crucial mechanisms for altering the strength of synapse among the neurons in neural networks. They further pointed out that on seeing yellow rose, a blue ball or a sound note, a group of neurons fire together in that particular cortex to form it into an experience. The pattern of firing among neurons remains encoded in the neural networks and causes to fire neurons even after stimulation ceased to exist. This is because we can visualize a yellow flower and a blue ball in mind even though they are away from the sight and likewise to the musical note also. This phenomenon is referred to LTP, which is crucial to the formation and storage of memory. Amaral and Soltesz (1997) showed some evidence suggesting that the chemicals released in the process of LTP might cause change of proteins or their synthesis and changes in gene transcription. Rabenstein et al. (2005) mentioned the study done by Diamond in 1988 on neuronal plasticity, which was the result of long-term Potentiation. The connection between two neurons will be strengthened only when two neurons are activated at the same time in the hippocampus. The impact of such activation may continue for hours or days and bring permanent changes in the network of neurons. Wolfe (2010) says, "The more often a pattern of neurons is activated, the efficient the associated synapse becomes" (p.149).

Working Memory

According to Wagner (1996), some scientists believed working memory as a part of short-term memory, and others thought that they are separate parts. Cognitive scientists understood that working memory, which is temporarily activated, is a portion of long-term memory. It is contemplated that this process allows the learners to link the current experiences with the previous experiences, which make their neural connections strong to result in retention. McGaugh (2003) observed that stabilizing the memory trace immediately after learning causes the formation of long-term memory. The complexity and variation between short-term memory and long-term memory can be understood with strength of memory trace. Torgesen (1996) explained that now a days the scientists prefer the term "working memory" for "short-term memory" which includes "sensory memory" as both of them process information for a short time. B.F. Pennington calls working memory as "computational arena" where the relevant information from neural networks to the current task will be maintained in the consciousness to process further. Wolfe (2010) stated that most of the scientists conceded that the memory is a multifaceted and complex process because it activates many neural circuits in the portions of the brain but they disagree on the uniform model.

Chugani (1998a) studied that repeated practice set working memories down as permanent neuronal circuits of axons and dendrites and ready to be activated at the time of need. When memory was recalled several times, its neuronal circuits were highly developed and repeated firing of neurons sync with one another caused formation of inter-neuron connections. When the connections grow stronger, then only one neuron triggers another connected neuron. Antonio Damasio (1994) studied that the recalling is the activation of all the separate sites in unison, and creating an integrated experience. He stated further that the only definitive elements are sufficient to recall an item because brain has the capacity to refabricate information to fill the gaps of information from the previous experiences only. In the absence of such previous experiences, the brain cannot refabricate the required information. Therefore, the people recall them by reconstructing all the bits of information relating to the event. Coles (2004) observed that the new data can remain long enough in working memory to have comprehension only when it has recognition link with the already existing data and also stated that the mental manipulation (cognitive processing in the prefrontal cortex) of such data through recognition link provides greater chance to the data to be stored into long-term memory. According to Willis (2008), working memory has the ability to hold information about 20 seconds and manipulate information to use in immediate future. The challenge for the learners is to move information from working memory into their long-term memory. Information must be processed into network of the brain's wiring to protect the newly learned information from slipping away.

Peterson, Carpenter, and Fennema (1988) summarized the research of PET scans that showed the distinction between the capacity of brain to develop a new skill and use it. The brain recognizes the particular stimulus and fits it into an established category, which is correlated, with the neural activation in the association-recognition systems. When the stimulus is not recognized as associated with previously stored data, it will be stored as a new recognition category. McGaugh, McIntyre, and Power (2002) studied about regional brain sub-specialization using neuroimaging technique while the subjects involved patterning, sequencing functions of concepts of print, turning pages, and reading print in the right direction. They found some sections within the prefrontal cortex especially active during judgment, analysis, prioritizing, organizing, directing selective attentive focus, and sequencing. Therefore, the working memory involved in higher cognitive "executive functions" like planning, organizing, and rehearsing. It resembles the work of CEO of a company. However, there are certain limitations on working memory:

- It is studied that information will be held in the working memory only for 15-20 seconds without any rehearsal or constant attention (McGee & Wilson, 1984).
- Working memory cannot process two trains of thought at the same time. Brain cannot focus on a particular conversation in the midst of many conversations, which is termed as 'cocktail party effect'. However, brain focuses on relevant and louder conversation than others. This is the reason for the problem that the learners face, when teacher wants them to listen to something when they are engaged in reading.
- Working memory cannot manage much information at one time.

George Miller (1956), cognitive scientist studied that working memory can process only seven items at a time. He called it as 'magical number' and featured it as a span of immediate memory. Pascual-Leone (1970) observed that manageability of number of items in the working memory varies with age. The number of digits that the children could accurately recall increases one for every two years of age. By the age of 15, they will acquire the capacity of holding seven items. As working memory is not a passive storehouse for discrete bits of information, the above study cannot be applied for every learning situation because some bits of information are held passive while some relevant bits of information to the task are manipulated. It is interplay of processing and storage. Therefore, it is unpredictable to measure while doing real-life tasks (Towse, Hirch, & Hutton, 1998). These limitations can be overcome by different ways of manipulating information in the working memory through chunking and elaborative rehearsals.

Consolidation through rehearsal

Gazzaniga, Ivry, and Mangun (1998) stated that the consolidation would be enhanced by only **rehearsals** in their book "*Cognitive neuroscience.*" The replay of experiences gives ample scope for consolidation. It made one thing clear that understanding information is not the forming of memory. It is an unconscious process rather than fixation because it takes days, weeks, or months to strengthen and stabilize the connections. Schachter (2001) presented the report of the N-methyl-D-aspartate (NMDA) which cleared that the receptor opens when it receives two different signals approximately at the same time and triggers "long-term potentiation" and it is believed to enhance synaptic connections. Nakazawa et al. (2002) reported that the memory consolidation is possible with the neurotransmitter acetylcholine and the **retrieval** of complete memories with incomplete set of cues is related to the activity of this receptor in hippocampus. According to Murchison et al (2004), norepinephrine is responsible for retrieval of memories through the hippocampus. Fujii, Moscovitch, and Nadel (2002) observed that the networks change in correlation with the growth of memories. Everyday life events appear to depend on networks in the hippocampus but overtime these memories increasingly depend on the networks in the region anterior cingulated cortex.

Wolfe (2010) explained that the consolidation appears to be the result of biological changes with the retention of information. In other words, consolidation is the outcome of integral function of hippocampus and other structures in the medial temporal lobe. As long as the learners practice or repeat the experiences, the associated memories will be consolidated. After the completion of consolidation, the connection between the hippocampus and cortex will be cut off. This process of consolidation may take years to complete. Brashers-Krug, Shadmehr, and Bizzi (1996) studied that learning motor skills also involves consolidation. Willis (2008) mentioned in her book "*Teaching to the brain to read*" that Learning motor skills initiates various neural processes that continue even after the practice. It is also suggested that as the consolidation of motor skills relied on the same structures of medial temporal lobes, which are necessary for consolidation of declarative memory, the gap should be maintained between teaching two different motor skills.

Neuroplasticity

The ultimate results of consolidation turn to the plasticity of human brain. The term "Neuroplasticity" is referred to growth of neurons in the cortex of brain, the branching of dendrites, and size of synapses against the corresponding environnment. Marian Diamond, Mark Rosenzweig, and their colleagues conducted study on the development of the cortex of rats in different environments and understood that the architecture of the brain can be influenced by the environment (Daiamond, 1985). Wolfe (2010) reported William Green's extended study on Influence of enriched environment and suggested that enriched environment (changed environment) showed considerable growth in the thickness and weight of the cortices.

Diamond conducted another study on the growth of cortex of rats that were raised in their natural environment and suggested that exposure to nature causes more dendrite growth and heavier cortices than the growth of them in the enriched environment (Diamond, personal communication). Park (2004) studied that the size of cerebellum increases dramatically during adolescence and continues growing until the mid-20s. According to Wolfe (2010), whatever may the processes turn out to be one thing is clear that amazing changes occur in the neural connections of the brain when we learn, so the life span of those changes will be determined by the structure the teacher provides to facilitate the learning.

Long-Term Memory

Wolfe (2010) stated that whenever we think about hospital, the memory of antiseptic smell floods our consciousness. We can remember the 30 years old song, though we did not retrieve or practice it any time. When we meet a classmate after many years, his memories come to our mind as fresh as lilies, though we did not recall it earlier. Though we have not ridden a bicycle for many years, still we model the children how to ride. This shows long-term memory keeps information of decades to facilitate our minute-to-minute learning. Although information in long-term memory is permanent, we cannot assure its accuracy. We do not know the capacity of long-term memory unlike working or short-term memory but it is estimated that the long-term memory may contain a million of billion connections. The long-term memory involves two types of processes that are identified by Henry Bergson in 1911. They are conscious memory processes, which are termed by some scientists as declarative or explicit memory, and unconscious memory process, which is in the course of time termed as procedural or implicit memory. Wolfe (2010) opined that long-term memory is not permanent as we think but it is a continuum between 'quickly forgotten' and 'never forgotten'. The great challenge to language learners is to transfer the word from 'quickly forgotten' to 'never forgotten'.

Declarative Memory

Cohen and Squire noticed that the medial temporal region of the brain is the location for declarative memory, which has the capacity to recall consciously every day facts and events and expresses explicitly (Eichenbaum, 2002). Wolfe (2010) pointed that the formation of this memory requires our conscious process like speaking or writing. The recalling of stored memories and describing a past event will be stimulated only by conscious process in declarative memory. The dual function of recalling and describing led to episodic memory and semantic memory.

Episodic Memory

Squire and Kandel (2000) called episodic memory as "source memory" since it remembers information of location and the time of an event in their book "*Memory from mind to molecules*". It records the autobiographical information like the faces, facts, and experiences. As the brain does not store information in linear format, memories will be reconstructed from neural networks where they were stored when we learnt. However important and emotional the events may be, still we forget some details. The brain refills the lost information through the process of "refabrication" which reconstructs the memory with the bits of truth. The embellished information while telling the stories will be fixed into memory repeatedly. Though the details may be inaccurate, the event of memory will be vivid.

Semantic Memory

EndelTulving differentiated semantic memory from episodic memory and defined it as a body of one's world knowledge, and the organization of memories is not bound to any specific experience (Eichenbaum, 2002). According to Wolfe (2010), Semantic memory involves words with their associated figures, regulatory rules to manipulate words, figures, and relevant definitions. It holds accurate information. She provided instances for both semantic and episodic memories; telling 5x4=20 is the example for semantic memory and information of the class in which we learnt table is the example for episodic memory.

Procedural Memory

According to Squire and Kandel (2000), this memory stores information about how we do instead of what we do. As there is nothing to declare, it is non-declarative memory. There are two types of procedural memories; one type of procedural memory deals with the storing of routine actions, which is called 'skills' such as our daily or habitual actions. Since the skills are automatic in nature, we can perform them without conscious thought because automatic process serves as unconscious stimuli and response bond. Jerome Bruner, cognitive psychologist called the procedural memory as "memory without records". Some skills like driving a car and brushing teeth involve motor activity while other skills like reading and decoding words do not require motor activity. In the reading skill, eyes moves slowly from word to word in the beginning but the more practice of reading the less movement of eyes. The skilled readers move their eyes four times a second and perceive the meaning of more than 300 words a minute.

Schacter (1996) explained about the second type of procedural memory as priming which involves impact of experience but not supported by conscious memory. It is also similar to skill learning because it does not activate conscious memory. So sometimes, both the skills and priming are called implicit memory. Wolfe (2010) mentioned a study in which the learners recalled many words that were already seen before when the words list is given with initial letters of the words, after some days. So they recalled better from procedural or implicit memory than from declarative or explicit memory. Squire and Kandel (2000) studied that the less neural activity is required to process the same word on fragment completion task after some days of first sight. This is learning procedural skills without having consciousness of learning them. Thus, procedural memory gave evidence about the existence of unconscious mental activities (Wolfe, 2010).

Forgetting

Schmitt (2000) stated that forgetting is as natural as learning and partial vocabulary knowledge will be in state of flux in between learning and forgetting until the words are stored in memory. The research shows that spatial learning is considered the best remedy for forgetting only when recycling of word can be done by way of using it in different contexts from the first context in which learner met the word rather than repeating them in the same context. Thornbury (2002) stated that learners forget the words even though they learn them with will. As a rule, forgetting is quick in the beginning but gradually slows down. It is thought that approximately learners will forget 80% of the matter within the 24 hours of initial learning but then the rate of forgetting comes down.

Neuroscience on Memorizing Vocabulary

Beeman and Chiarello's (1998) neuroimaging research study noticed that the neural subsystems were stimulated for recognizing speech sounds, decoding written words, finding the meanings of words, comprehending complex text, making inferences, analyzing, and using information from the reading to make new associations. Gazzaniga, Ivery and Mangun (2002) studied that each lobe and hemisphere were somewhat different in their action. Both the frontal and medial temporal regions involved in memory formations of verbal and spatial items; right frontal cortex memorized non-verbal items like faces or a picture of an object whereas left frontal cortex memorized words and also dealt with issues of remembering and forgetting. Similarly, right occipital lobe recognized the faces based on fine perceptual discrimination whereas left occipital lobe was important to recognize letters and words. Abadzi (2003a) reported that the word superiority effect stimulate the recognition of individual letters within a letter group which conforms to the spelling rules and thus identifies the word.

Coles (2004) reported fMRI and EEG scans research, which showed the connection between brain's response to written text and metabolic activation in the alerting-association systems in the posterior left temporal and occipital lobes. According to the study, the stimuli that passed through the affective filters, and alerting systems activated the areas of stored related memories to consolidate data between the new data and the data already stored. Martelli, Majaj and Pelli (2005) found that the brain recognized letters by parts, not as wholes. Our visual system recognized bite-sized pieces and assembled them into perceptual objects that constitute our environment. This may be one reason why the "phonics" oriented method turned to be effective than "whole language approach." Thornbury (2002) stated that learning vocabulary is not simply holding words in our head for a few seconds but it involves different kinds of operation to send the word into long-term memory.

Conclusion

According to Wolfe (2010), memory enables the learners to learn by experience. She further states that people cannot respond properly to environmental dangers if they have no ability to learn, store, and recall. She emphasized the need to understand the memory process as educators to make the learning meaningful to the learners and to be used for their survival. This paper provided theoretical assumptions based the findings of some studies on human memory process. It showed the division of functions of brain in the process of moving the learning content from sensory memory, which like a sieve filters unattended enormous data, to long-term memory, which is not permanent, through the working memory where the stored data will be retrieved, manipulated, and consolidated. The paper appeals to the ESL learning and teaching communities to understand the storing, retrieving, and consolidating procedures of learning so that they can evolve their own strategies to enhance L2 vocabulary memory, which further keep English language learning incremental and brisk for bright future.

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