Research Article

Neurology - Research & Surgery

Human Memory and Recall: Bridging the Gap between Encoding and Recall of Information

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Received: 26 November 2018; **Accepted:** 23 December 2018

Citation: Tamara C. McGill-Carter. Human Memory and Recall: Bridging the Gap between Encoding and Recall of Information. Neurol Res Surg. 2018; 1(1): 1-11.

ABSTRACT

This article/packet includes a proposal that presents that the student is intending to conduct the research on memory encoding by including research questions, a purpose statement, and a problem statement so to give an outline of why such a subject should be researched and/or studied. The literature review is presented secondly as it gives detailed information into the subject of memory, although it summarizes previously published research. Data on Time Decay, certain genes involved in memory encoding, and even experiments replicated from previous researchers are included as well. Lastly, peripheral documents are included as they tie the entire packet together such as the chosen journal publication criteria, the letter to the editor of the journal the author has chosen, and the actual article itself.

Keywords
Hippocampus, Cingulated gyrus, Subcortical.

Proposal
Topic
Title: Developing a research article to understand Human memory and recall: Bridging the gap between encoding and recall of information.

Research Questions
How efficient is human memory in encoding information?
How much time elapses between the storing of information and the voluntary/involuntary recall of the information stored?

Purpose Statement
The purpose is to write this qualitative based research article to understand exactly how human memory functions in storing information and how time makes a significant difference between the storage of the information and the recall. This article will demonstrate how different forms of information such as high and low frequency words, cognitive tasks, and involuntary spontaneous recall of information previously stored are encoded, recalled, and the significance time makes when the encoded information is called on either voluntarily or involuntarily. The main purpose is to understand how the memory stores information into the Primary Memory (Short Term Memory) and the Secondary Memory (Long Term Memory). The hippocampus works in storing the information that enters the brain via the superior and/or inferior colliculus. The importance of Short Term (Maintenance Rehearsal) and Long Term Memory (Elaborative Rehearsal) functions will also be explored in this article as they play a significant role in memory functions.

Problem Statement
Memory differences over the short term and the long term memory has been thought to differ in many ways in terms of capacity, the underlying neural substrates, and the types of processes that support performance [1]. With certain functions such as cognitive tasks and high and low frequency words, the memory works to process the information that enters the brain and categorizes the information in either short term (working memory) or long term memory, depending upon the information being stored [2]. Research into the human memory has yet to understand exactly how short and long term memory works in storing information. This is largely due to a lack of converging evidence on the construct of attention in memory research [2].

Long standing and recent research into memory has found substantial evidence and characteristics that separate short and long term memory and models have been designed to make clear the differences between the two memory systems [3]. Researchers have identified that the human memory is separated into two memory systems: Primary and Secondary memory. Primary memory has been identified as the Short Term Memory and the Secondary Memory is referred to as the Long Term memory [1]. In understanding the difference in these memory systems, one is concerned over the amount of information that can be maintained in each system. Primary memory or STM is limited in the information that can be maintained while secondary memory or LTM is infinite in the information that is maintained in that system. A further point of separating PM and SM concerns the differences in the type of encoding, maintenance, and retrieval processes involved in performance on tasks thought to tap into the two systems. For example, with primary memory or STM tasks that require remembering a series of words and/or names of others, one tends to rehearse the words and their performance is better when they can do so without distraction. On the other hand, with secondary memory or LTM tasks, it is usually possible to rehearse a long list after only a single presentation or to continuously rehearse even a short list over a long delay.

Another source of evidence for the existence of the two differential memory systems is the damage to the brain that will make processing and later retrieving memory impossible or delayed, especially damage to the hippocampus, which relays the information to the two systems after entering into the brain. This comprehensive qualitative research article will take a trip into the human memory to understand how both memory systems function separately and in unison when certain tasks, recognition, recall, and maintenance of information is tested against both systems.

Literature Review

Encoding of memories, much like the elusive study of the human memory itself, has become one of the most widely studied areas of neuroscience throughout history. Since the first recorded brain injury back in 1881, researchers have been studying the encoding, storage, and retrieval of information and how such a process works. While it has been discovered that the brain does have numerous memory systems, the long term memory storage has clear cut research that points out how the long term memory storage functions in encoding and storing memories while research on the short term storage has limited information concerning how this system plays a role in the storage of information into the long term system. In this literature review, numerous research studies concerning memory encoding will be discussed such as depths of processing, emotional events that leads to memory encoding and later recall over non-emotional events, and how advanced technology captures the perceptual brain regions in which memories are encoded and later retrieved. Constructs from the beginning neuroscience era to the conclusions of the modern research surrounding this topic, the gaps in the research of encoding, and the strengths/weaknesses/implications will also be discussed.

Brief Background

Memory encoding became a fundamental subject since the discovery of the limbic system, otherwise known as the emotional brain [4]. The term limbic stems from the border in the brain in which the limbic system sits, separating it from the other cortical/subcortical structures that sit beneath the cerebrum [4]. The limbic system was discovered to process and encode memories based on emotional responses to events that were perceived through vision and auditory. The subcortical structures that have been associated with the processing of emotional memories are the Prefrontal Cortex, Amygdala, Anterior Cingluate Cortex, Hippocampus, and the Insula [5]. However, within these structures, the hippocampus and amygdala have been the most studied structures that were found to process emotions related to memory encoding, thus processing and storing them in the long term memory system [6,7]. To take emotional memory processing a bit more further, a journal article by William James (1884) entitled "What is an Emotion" brought into perspective one of the most thought provoking questions about emotions and how they can possibly be related to memory encoding. James proposed an innovative theory whereby human emotions occurred in response to afferent feedback loops from the sensory receptors in the skin, muscles, cartilage, and other organs which produced physical changes alongside the emotional experience [7].

These changes were later encoded into the cerebral cortex memory storage to determine the exact quality of the stimuli experienced [5]. According to this same theory, emotions are just one form of experience of a wider array of physical changes that occur in response to emotional stimuli, also needed for human survival. James understood that different memory processes encoded different emotions as they entered through the brain through afferent nerve pathways [5]. In contrast, a study of human emotions conducted by Walter Cannon, a Harvard physiologist, argued against James' theory of human emotions. Testing James' theory in a laboratory setting, cannon concluded that human emotions, when provoked and studied in a lab setting, cannot be maintained in these states of arousal for further studies beyond being provoked. In comparison, the two studies of emotions by both researchers were valid in understanding how the emotions were linked to memory encoding. However, the hindrances in Cannon's studies were his artificial creation of emotions in the lab setting that could later be linked to encoding memories. Cannon failed to realize that emotions occur naturally and while occurring naturally, produce a natural reaction from the brain that will later encode the memory of what created such a reaction, a chunk of information that was left out of Cannon's theory of emotions and encoding. But without the creation of artificial emotions, what truly creates the memory encoding preceded by emotions?

Gold & Squire [8] and Squire & Wixted [9] partially answered this question as they provided their fruitful insights into how memory encoding can be compromised in the event of brain damage with their study of a patient by the initials H.M. whom experienced memory loss in the wake of the patient's surgery [8,9]. The medial temporal lobe, which houses the hippocampus and amygdale specifically, became a central study in the event of brain damage that prevents the creation and encoding of memories. These findings pointed out the memory encoding is a distinct cerebral function, separate from the brain's other cognitive functions [4,10]. After the study of H.M.'s encoding/memory defects, the name regarding this particular defect was later named Korsakoff's syndrome, after the Russian psychologist Sergi Korsakoff.

Depths of Processing Framework for Encoding

The depth of processing pertaining to the memory system has been thoroughly studied in the neuroscience field ever since the discovery of the two distinct systems. There has been frequent criticism that has attacked the distinction between the two systems and their depths of processing information related to encoding and to be remembered items for the past 30 years. In wanting to end the criticism regarding the memory systems, Anne Treisman (1964; 1979) proposed the theory of Selective Attention that would test the "levels of analysis" of each system store to determine what was later going to be encoded into storage. The levels were seen as a hierarchy running from early sensory analyses that focused on surface specifics (shallow processing) to lower analyses concerning specific object classifications and specific sounds of words and dimensions of pictures (deep processing).

In light of this theory, being able to identify and recognize the certain meanings may be regarded as what could occur later in the sequence of analytical "tests" when those signals enter the sensory system to be encoded [11]. Treisman (1979) also theorized that incoming information is subjected to a series of sensory level "tests" at which each level of processing and only certain aspects possessing certain dimensions of the incoming signal will proceed to the next level of analysis. The experiment to understand selective attention was conducted under five conditions (1) meaningfulness, (2) loudness, (3) brightness, (4) contextual relevance, and (5) recent experience [11]. In the start of the experiment, all sensory signals were taken in normally as any background noise would when produced under those conditions. Later, each condition was measured according to how the participants responded under the continued condition and loudness, brightness, and meaningfulness stood out to the participants of the study [11].

After the study, a conclusion to the selective attention experiment resulted that certain sensory signals require more attention than others, thus answering the hypothesis of Selective Attention in the levels of analysis. This study was important to note in the field as Criak [11] wanted to understand the exact dimensions of what it took for Selective Attention to take place. While the participants of the study were very few, the results of the study still gave Criak [11] the answers behind Treisman's study. After several replications of the study, Criak [11] made a note that levels of analysis for Selective Attention would occur like this over an individual's lifetime unless a disruption, such as brain damage, took place. Thus, the hypothesis was indeed answered from the results of the experiment, however, considering the gaps of information provided in this study such as materials used in the research, number of participants, their characteristics for the study, and how the results were measured, the study is considered inconsistent by the standard of today's research study [11]. The strength of the study was the conditions of the experiment and the desired results that came about, answering Criak's question concerning Selective Attention. The weakness of the study was the gaps in the explained experiment as mentioned above. Criak [11], while interested in Treisman's experiment on selective attention, reenacted the experiment to understand how selective attention applies to Short term memory and the depths of processing of that system, aside from long term depths of processing.

By this view, Criak [11] argued that short term memory, also known as Primary Memory, is not a memory system store in any sense and is not located in one any place in the brain. Rather, short term memory has been researched to have a connection to the activations to what is closely correlated with our present experience in life, the function that plays a part in our daily consciousness, and thus short term memory system can be located in any number of the brain locations, solely depended upon the type of information being held in mind at the time [12]. Another description that could better describe short term memory is that maintaining an item in STM can be said it is to continuing to paying attention to the item in the direct line of vision.

Criak [11] along with Ekuni and Bueno [13] discovered this segment of maintaining an item in short term memory to be the working memory segment of the short term memory and accounts for the STM mystery of how one memory store could hold a variety of different types of information through visual and auditory (verbal), although other theories have also been proposed in the literature. Criak [11] conducted numerous experiments using verbal materials such to hear certain sounds, rehearse names, numbers, and other verbal materials. These research findings fit perfectly well with the present account of the short term memory system distinction from the long term memory system. The only comment on Criak's end is that additional cortical areas may also be involved in short-term retention and rehearsal if one maintained an image in mind.

One final thought to sum up Criak's short term memory riddle is that past and current research has supported that the short-term memory system has reflected to have recent activational link of the term memory system rather than necessarily reflecting on current in mind functions. Therefore names, directions, and solutions to problems may be particularly accessible if one has recently thought of them. From these experiments, Criak [11] found that using real world examples in order to understand how short term memory works did indeed give him the answers that he was looking for. By using names, certain sounds, and numbers, the short term memory did work as predicted. Through conducting this experiment, the strength of the study was that Criak [11] was able to use real world examples as a way of demonstrating the real use of the STM functions through the LTM activations.

With this conclusion of the short term memory mapped out by Criak [11], numerous experiments were done to test the depth exactly. The first experiment conducted was to measure the time it took to decide whether a word was or was not congruent with the orienting question, for example looking for a word that rhymed with another word such as Spain. Would the rhyming word be something like rain or another word close in association such as train? In the second experiment reported by Craik [11], the yes and no test based on decisions took about the same time at each level of analysis, yet words associated with positive rhymes and sentence structure decisions were better recognized than words associated with negative rhymes and sentence structures. It seemed, therefore, that processing time of the yes/no test by itself was an insufficient factor in determining the STM depth [12]. This was the only limitation to the study that was documented.

When the decision results test were plotted against the first experiment test results, a regular pattern emerged between the two experiments results. The results findings resulted that the yes/no decision times lied on a same scale next to the times of the first experiment related words patterns, meaning that both the depth and elaboration is a consideration before memory can be accurately predicted. However, the yes/no answer decisions test and the extra time needed for deeper processing operations displayed better recognition performance. With that, the first experiment did exhibit the results for which the experiment was looking for, thus the answers Criak [11] was looking for in terms of the depths of the STMN memory bank, measuring its depth exactly, another major strength of the study for measuring the depth of the STM.

Jonides, Lewis, Nee, Lustig, Berman, & Moore [14] further theoretically debated the nature of the STM, mostly surrounding its structure and capacity, but these authors focused more on the encoding process and its related functions to long term activation. Their view leads to a conclusion that the short and long-term memory systems are not separate memory systems, at least not in the sense of how each neural system functions for encoding. Instead, scientific evidence points to a model in which short-term memories are linked to activations of the long-term system. This model, much like numerous other models of memory, has a long history in cognitive psychology, with early theoretical ties to the interference theory. According to Jonides et al. [14] empirical research supports those memories in both the short and long term memory systems suffered from proactive interference of at some point before and during encoding. Perhaps the first formal proposal of this is that short-term memory, when functioning, activated long term representations were by Atkinson & Shiffrin. This theory fell somewhat out of favor during the development of the hegemony of Baddeley multi-store memory model, although it was given first detailed computational treatment by Anderson [15]. This model was revived by Cowan [16-18], McElree [19], Oberauer [20], Verhaeghen et al. [21], Anderson et al. [15], and others. The key assumption was the construct of very limited focus of attention, although there still are disagreements regarding the scope of the focus. It was noted that verbal rehearsal is perhaps mostly intuitively associated with STM and plays a key role in the classic multi-store model.

However, as discussed, rehearsal most likely reflects a complicated, yet distinctive strategy of encoding rather than a primitive STM process of encoding. Modern approaches to memory research now offers a large set of candidates including encoding and maintenance, attention shifts, spatial rehearsal, updating, overwriting, cue-based parallel retrieval, and interference-resolution [22]. Rather than navigating this complex and growing list of experimental growth, these authors took one cornerstone of the research and focused on the concept of limited focus of attention. The central point of agreement concerning STM is that there is a distinguishable focus of attention in which long term memory representations are directly accessible and available for cognitive action [22].

Encoding processes are the central part of traditional cognitive psychology theories of perception, but are not in any of the current accounts of STM. Jonides et al. [14] have outlined the three distinct assumptions about the encoding processes made in most research surrounding of STM. Firstly, the cognitive functions of the STM is assumed to have access to perceptual processing, that is, the focus may include contents from the present as well as contents retrieved from the past. Secondly, the current theories assume that encoding into the focus of attention results in the displacement of other items from the focus. Third and lastly, all of the research assumes that perceptual encoding does not have access to the immediate focus [14]. Instead, any encoding that takes place during focus is done solely by attention. These findings follow directly from the assumptions about the limits on focus capacity: There must be some way of controlling aspects of attention which present focus, as well as the cognitive past. The important points that these authors were trying to achieve was that certain theories and research surrounding this area of memory has important notes to consider, but mostly focused on the attention and access to past information via the STM. The aim here is that it is important to know how attention as well as other aspects of this memory system functions to be able to get the entire picture of STM as well as its activational link the long term memory system.

Jonides et al. [14] built on these findings and suggested a new view of capacity. They proposed that attention focuses on what is known as a single functional context, whether that context is defined by time, space, or some other stimulus characteristic such as semantic or visual similarity. By this, attention can be placed on a simple number system functional at "3+4," allowing simple and relevant computations to be made.

Unitary-store models proposed by earlier authors alongside Jonides, et al. [14] described the Short Term Memory system capacity as limited by the number of items that can be stored and activated in the long term memory store. However, these models differ on what that number could be. Earlier research suggests that a strict number limit of four items based on performance such as errorless performance in immediate recall when the number of items is less than four, and increases in errors for larger numbers. Therefore, the classic "seven plus or minus two" is an overestimate because it is based on studies that allowed participants to engage in processes of rehearsal and chunking items for better recall. The comparison of both studies of the STM done by Craik [11] and Jonides et al. [14] provided an abundance of information concerning how the STM memory functions in holding and later encoding memories while also giving a little bit of background of how the system has a link to certain LTM activations for encoding that which will shift from short term to long term storage.

So what is said about Long Term memory storage and the levels of processing in the literature? Rose, Myerson, Roediger, & Hale [3] points out that one characteristic of LTM is that it is highly sensitive to the depth with which memory items are processed when they are initially encoded. It is well established in the literature that semantic processing at encoding leads to superior long-term retention on most episodic memories, relative to the processing that focuses on more structural aspects of the memory items, such as phonological meaning of words and/or visual features of objects. However, if the performance of working memory depends in part on retrieval from the long term memory, then it would seem that the type of processing at encoding should affect the performance on WM or short term memory functions [3].

More specifically, if one were to design a WM span task in which the task involves varying levels of processing, then one might expect semantic processing to result in better immediate recall such as increased WM span and the focus will be more on attention more than structural aspects of the memory items. Rose et al. [3] conducted an experiment which presented participants with five words for immediate free recall. Participants were instructed following presentation of each to-be-remembered word, they were to process that word in one of four different ways, depending on the condition: rehearse the word silently, rehearse the word overtly, generate a rhyme, or generate a semantic associate.

The documented strength of this study was that the first two rehearsal conditions both produced near-perfect immediate recall, which was considerably better than the performance for the second two, and last rehearsal conditions. Interestingly, the last two conditions that most closely resembled a complex WM span task requirements failed to show an LOP effect, which posed as a weakness to this study [3]. That is, generating a semantic processing did not produce significantly better immediate recall than generating a rhyme. By producing certain conditions for producing immediate recall, the LOP effect is showing the depth of the LTM, knowing that a certain condition would help one with immediate recall of the item.

To further elaborate on the functions of the memory systems, emotional and stressful events connected to memory have been linked to information processing and encoding. The question was posed whether just emotional responses gained more influence in the memory than non-emotional responses. Dolcos & Cabeza [23] & Labar & Cabeza [24] states that emotional events are better remembered than unemotional events. Most studies have focused on the perception and evaluation of emotional stimuli and on the effects of emotion on memory formation. A critical distinction in the literature on emotional encoding is between two affective distinctions of emotional memory processing: emotional arousal and emotional valence. Arousal simply refers to a state that varies from calm to excitement, whereas valence simply refers to a state that varies from pleasant to unpleasant, with neutral as and intermediate distinctive value [23,24]. Different approaches ranging from behavioral and pharmacological to electrophysiological and functional neuro-imaging have tried to define the anatomical and functional correlates of emotional processing and emotional memory.

Taking a closer look into what could possibly create an enhancing effect of emotion-memory correlation, Dolcos & Cabeza [23] gathered fifteen female right-handed university students from the Duke University. This particular sample was chosen due to the historical knowledge of women displaying more of a physiological response to most emotional stimuli than men. The sample was presented with a pool of 180 pictures that were chosen from the IAPS (International Affective Picture System) as pleasant, neutral, and unpleasant. Pictures were rated on a 9-point scale arousal scale with number one being the least arousing and nine being the most arousing. Another procedure called an Emotion Response Potiental (ERP) Recoding cap was also used in conjunction with the picture pool during this study to record the physiological responses of the mastoid muscle in response to the stimuli presented [23]. Ag/AgCl electrodes were embedded in the cap to give a read out of the muscle's response to the given stimuli. For this procedure, the reactions of the subjects were rated according to the 5 point scale of reaction with 1 being very unpleasant and 5 being very pleasant.

The results of this study from the ERP recording produced the results that the authors were aiming for which were the reactions to the pictures of the very pleasant to the very unpleasant. The very unpleasant pictures presented to the sample registered a 5 from the group and was recorded using the ERP [23]. As hoped for, the authors got the answers regarding whether preceding emotions to excited stimuli will aid in encoding of very unpleasant stimuli into the memory system for storage. The emotional response data to the neutral stimuli using the ERP was also recorded as hoped for, neutral stimuli doesn't become encoded due to the lack of emotional response to the stimuli. In a similar study by Payne, Jackson, & Hoscheidt [25] concerning stress and memory encoding, these authors found that stress profoundly influences memory in humans and other species. This is due to the of the hypothalamic–pituitary–adrenal axis, which releases stress hormones and assists in signaling the release of glucocorticoids (GCs) from the adrenal cortex. Many of the brain regions important to memory such as the hippocampus, prefrontal cortex, and the amygdala have dense concentrations of GC receptors and the function of these regions can be influenced by increased stress hormones [25]. Through their studies, they have found that stress and/or GC treatment can either impair or enhance memory performance, depending on several factors. One such factor is memory stage that controls encoding, consolidation, and retrieval [25]. Glucocorticoids, interacting with adrenergic activation in the basolateral amygdale and the hippocampus appear to impair delayed memory retrieval, but enhance memory consolidation. Although a better understanding of the impact of stress on memory consolidation and retrieval in humans is becoming clearer in the literature, it still remains unclear how stress is initiated prior to encoding than what affects later remembering [25]. Nonetheless, examining the impact of stress on the long-term memory retention is important because it reflects how stress often operates in the real world. Stress can occur prior to or during encoding of an event that one may need to remember sometime later such as in the case of eyewitness testimony.

Payne et al. [25] further elaborated that memories for emotional and neutral information contained within a single episode were differentially affected by pre-training stress episodes, i.e. neutral information was disrupted while emotional information was preserved relative to a no-stress control group. During the study, these authors were unable to confirm that emotional information was in fact enhanced by stress exposure, that is, they failed to find the crossover where stress both disrupted memory for neutral information and enhanced memory for emotional information, and that the observed effects were due to measured changes in stress responsivity [25].

However, in a more updated study done by Payne et al. [26], stress was initiated before encoding. However, this time, they aimed to examine its impact on the long-term retention of separate emotional neutral episodes and to determine whether changes in memory performance would correlate with measures of stress responsivity (cortisol, catecholamines, heart rate). They predicted that stress would enhance memory for emotionally arousing negative material, but disrupt memory for emotionally neutral material, and that both of these effects would be driven elevations in stress hormones [26]. The study was extended for the possibly of forming false memories in sleeping participants [26,27], followed by a short study concerning false memory formation in schizophrenics [28]. Neither had reliable evidence and results for either study.

Despite the two studies that took place by these authors, there was a limitation to their study and that was between both studies conducted by these authors. The limitations did not separate stress effects at encoding from those on early consolidation processes. However, they accepted this limitation at the design stage of the study because it was to mimic what often happens in the real world, where stress precedes encoding and thus influences both encoding and early consolidation processes [26]. Nonetheless, this flaw came at a cost as they had no way of determining when the results were going to occur because of the synthetic arousal of the emotions during the study. Previous research provides evidence for both possibilities. Payne et al. [26] study provided that stress can produce neutral memory impairment and emotional memory preservation after a brief delay, which suggests that encoding processes could support these findings. On the other hand, several pharmacological studies suggest that their results are more likely due to influences on consolidation [26].

Further Neuroscience Research on Memory

With both memory systems thoroughly examined from capacity, depths of processing, and even emotional processing, it is often overlooked in the literature about memories that are formed, but never retrieved or even maintained. So what happens to those pieces of information? Any information that enters into the memory systems exists for a limited time and in a liable state. However, with the passage of time during the healthy functioning conditions of the RNA and protein synthesis, that information becomes stable and insensitive to disruption, a process that has come to be known as memory consolidation. Albernini (2009) points out in this particular area that several transcriptase genes related to the synaptic plasticity of long term memory formation are CREB, CREM, and ATF-1.

These genes have been found to function within the RNA and protein synthesis operations, with CREB being the most critical transcriptase gene to create the stability of synaptic plasticity that help form long term memories [29]. With disruptions of the natural biological functions of the RNA, protein synthesis, and damage to the genes responsible for memory formation via strong neuron plasticity, this has added up the theory behind "Time Decay", in which memories fade/is lost over time if the information is not maintained or retrieved from memory within the allotted time [30].

Time Decay otherwise known as "Forgetting", has been to be directly linked to the atrophying of the CREB gene and the malfunction of the chromatins, which has been found to be linked to learning and memory as well [30]. Without proper maintenance of the information and the breakdown down of said biological and genetic factors, Time Decay will begin to process.

Hanslmayr, Staudigl, & Fellner [31] in conjunction with a study done by Murty, Ritchey, Adcock, Alison, & Labar, [32] found brain oscillations to be another influential biological function that contributes to the formation of long term memory consolidation and retrieval. Brain oscillations control the excitatory or inhibitory functions of the post synaptic potentials that regulate fluctuations in the local field potential of the hippocampus and increases in the theta. Gamma frequency range in this area play an important role for memory formation and retrieval via maintained synaptic plasticity and coordinating the biological functions that reactivate the memory [31,32].

However, the research has also found that a decrease in the alpha and beta frequency range is very strongly linked to semantic (deep) processing of memory. Thus, Hanslmayr et al. [31] discovered through replication tests using several MRI's and EEGs that Subsequent Memory Effects (SME) have opposing effects with different frequency ranges within the prefrontal cortex and hippocampal structure. The findings in the replication studies discovered that positive SME's along the theta and gamma bands increase in power for subsequently remembered items and along the alpha and beta frequency band, the power decreases for subsequently remembered items [31]. Both frequencies were tested against shallow and deep processing of memory encoding conditions, testing whether the brain's oscillations could differ between the SME's of both conditions. While both frequency ranges function differently in the brain's oscillations, they both are efficient in encoding memories into long term storage [31].

Conclusion

Through the many years of research concerning memory, there have been pit falls as well as victories in uncovering what memory truly is. As what was summed up and analyzed here, memory is not just one thing, but many things. However, what was specifically pointed out is that numerous functions such as biological functions of RNA and protein synthesis can help consolidate the memories via neuron plasticity (stability of the neurons so they care produce healthy firing of information/neurotransmitters) while the malfunction of certain biological functions like the chromatins can contribute to forgetting or time decay of information/memories.

While some studies displayed better successful outcomes than others in the search for the elusive memory bank, the studies that displayed weak results in the search could have been stronger in the experiments and results segment of the research conducted. By doing so would have displayed a strength so that other researchers may replicate the experiment as such was done by Craik [11] in Treisman's Selective Attention study. For future research conducted in the neuroscience field by future researchers, it is hoped that the findings and ideas from cognitive neuroscience may combine with findings and ideas from experimental cognitive psychology over the course of the next 30 years to provide a deeper understanding of what memory is as well as how it functions in further detail.

Methodology

The purpose is to write this qualitative research article to understand exactly how human memory functions in storing information and how time makes a significant difference between the storage of the information and the recall. Memory differences over the short term and the long term has been thought to differ in many ways in terms of capacity, the underlying neural substrates, and the types of processes that support performance [1]. With certain functions such as cognitive tasks and high and low frequency words, the memory works to process the information that enters the brain and categorizes the information in either short term (working memory) or long term memory, depending upon the information being stored [2]. Research into human memory has yet to understand exactly how short and long term memory works in storing information. This is largely due to a lack of converging evidence on the construct of attention in memory research [2].

Data Search

Using the Chicago School Library EBSCO Database, the psych articles data base was chosen for the search and the following key words were entered into the search: memory, short term, long term, recall, encoding, consolidation, and brain injury. The purpose in using these specific keywords is to ensure that the keywords match up with the specific research and that the information being searched for is accurate. However, when locating the appropriate sources to include in the literature review of a professional article, the number one aspect of a source that will provide meaning to the research is creditability. The creditability of the source that one is searching for to be included in the article is the most important as decades of empirical research proves that said source has been tested and replicated by researchers and has a history and proven results behind it. Focusing on the database in EBSCO Psych Articles, the results highlight the abstracts of the journal articles. The abstracts of the journals give keywords as well as the subject related information pertaining to the search. Specifically any information regarding memories and the encoding of are very significant/important sources to be used in writing a literature review or a research paper. However, the overall goal in searching the literature for this particular subject was to get a basic as well as advanced understanding in how the human brain creates, encodes, consolidates, and when a memory is recalled, how the memory systems function in retrieving said information/memories.

Design

After using the EBSCO Psych Articles database, this qualitative research article was placed together by first giving the history of the human memory, as early as it began. The first study concerning human memory began after the first brain injury recorded in the year 1881. The history is normally the shortest part of the article, but should always be introduced first.

The second segment of this research article is the brief background of the human brain, also known as the germinal theory, how the brain works in its entirety or in part of how the brain works in producing and storing memories. This part of the article gives an introduction as well as explanation as to how certain brain structures work together in producing the responses as well as functions to encode the information that enters the brain. The next theme placed in this article focuses squarely on the depths of processing for the two memory systems. Numerous experiments and tests by various authors/researchers were explained in this area to discover how each of the systems worked together as well as apart. The first memory system mentioned is the primary memory, or STM and much debate surrounding this system as an actual memory system was discussed by Craik [11]. Craik [11] replicated Anne Triesman's experiment of Selective Attention to better understand the required sensory level "tests" of analysis that each piece of information that enters the brain must reach for encoding to take place. This was an important experiment to note because it explains how information is processed in the brain for later retrieval, if encoded. This experiment was conducted to understand not only depth of the STM, but also the LTM or secondary memory. Numerous more experiments, models, and the LTM functions separate as well as with the STM were mentioned to give an explanation of how the system works in encoding and retrieval of memories.

The next segment to be sequenced is the future direction/research and conclusion of the subject. This segment gives other authors a direction to follow if/when they are looking to do research in this particular field. While information researched for this article came together very well, there were a lot of information that had to be filled in where the articles researched to put this article together left out/failed to provide. This segment of the article is important as future researchers can benefit by digging deeper into their research to fill the gaps that were left.

The author will seek publication in the Journal of Neurology: Research and Surgery. This journal focuses on articles on the specific topic of neurology, the research of the human brain and surgery. Each contribution will be relevant to human language and to any aspect of the brain or brain function. This document will be submitted as a brief review of 5,000 words or less (including figure legends and references). Typically such articles include Introduction (including a brief statement of methods), Results, and Discussion, followed by a short section on Methods that will appear at the end of the manuscript. Methods already published should be cited and not restated. Short communications may have up to 3 Figures/Tables that take up at most 1 full journal page. Such articles will earn rapid review and decision, and will have priority for priority publication.

This article will discuss how memories formed through different techniques such as emotion-focused encoding, how Time Decay is achieved through the atrophy of certain genes located in every biological functions, and how emotional responses are scaled based on the picture responses provided. Several options/techniques are explained in the literature as to how memories/information is encoded into the human memory starting with the brain's main memory structures all the way down to how certain tests that were provided to test the depth of each system to determine just how much information each can hold when information is encoded.

Procedure

The literature review for this project was organized with an overview of the Human Memory, the correlating brain structures that work in creating memories, and the technology/procedures utilized in understanding specifically how the human memory works in doing so. It was particularly important to get to the depth of the creation/encoding of memories/information to give future researchers in the field a foundation to build their research on so more research can be created to fill the gaps of what this author and others previously have missed/wasn't able to fill the gaps when conducting the research in the field of neuroscience. A description of Ann Treisman's work on Selective Attention, later replicated by Craik [11], gave an interactive look into the short term memory, thus giving the foundation in understanding how the human memory systems function overall by the "levels of analysis" of each system store to determine what was later going to be encoded into storage.

Discussion

While this article has extracted the information concerning both memory systems and how memories are encoded into each by the sub-cortical structures, through the neurotransmitters, and the properly constructed neuron plasticity mentioned as well as the mentioned artificial and natural means of processing the information to be encoded from the selected literature, there are weaknesses as well as strengths that this article possesses that may or may not be evident.

The strengths that are clearly mentioned in the article are the experiments accurately replicated by the present researchers from previous researchers who originally created the experiments to test if each would produce the results that were sought after, to test whether the given experiments would provide enough data, information, and results for memory encoding. For example, an experiment done by Dolcos & Cabeza [23] and Labar & Cabeza [24] focused on memories and information being encoded via emotional (arousal) versus non-emotional (state dependant arousal) encoding, that emotional events are better remembered than unemotional events. The researchers have taken different approaches ranging from behavioral and pharmacological to electrophysiological and functional neuro-imaging to define the anatomical and functional correlates of emotional processing and emotional memory.

The weaknesses, unlike the strengths of this article, were not made evident. For further clarification, the weaknesses of this article were that no cultural, ethnic, and age considerations were included when the experiments were conducted on the subjects. For example when the fifteen female students from Duke University were selected for the emotion based memory encoding experiment, the ethnic background, culture, and age were not mentioned, thus giving a broad range of each area for the women selected for the study. The only limitations that was made evident in the literature of this article was that only right handed women were to be selected for the Dolcos et al. [23,24] experiment considering that they are known to be emotional, thus giving the researchers an advantage in the emotion based encoding experiment.

Considering that this article lacks ethical, diverse mentions, and accommodations for the experiments that were conducted, the author does intend to fully explore how such accommodations for ethical and diverse groups will be included for future researchers to replicate such as religious affiliations, cultural acceptance/rejections for such experiments, and even if the participant feels comfortable being a part of the experiment per their cultural and/or religious allowance of such participation. Considering the lack of the ethical, diverse, and cultural considerations of the aforementioned experiments done by the researchers, such expansion will be mentioned to clarify what is indeed missing.

For the majority of the literature review that synthesized the information concerning the memory experiments conducted, the researchers whom contributed to the articles mentioned did not have an aim for the specific population or subgroups in which they selected their participants from, but instead, chose random participants from the general population while not minding the culture, age, and gender of the participants chosen. However, one article written by researchers Dolcos et al. [23,24] particularly chose women for their memory study as it is documented in the literature that women are more emotional than men, thus gaining an advantage in their study of emotional memory encoding. This particular article did indeed target a specific gender as part of their study while the others were written and experiments were done concerning the general population.

Even though the article was published in two thousand and twelve, the peer reviewed articles are current while more articles on the subject of memory encoding are still being published. To include, this article did not contribute to the literature as it did more summarize what was already published previously, which is considered another weakness this article holds.

While this article did provide valuable information concerning the numerous memory encoding methods, for someone who were to read it for future research or merely look it through for leisure, no psychological harm will be brought to the reader and no risk of breaking confidentiality is involved since the participants who consented in the experiments' names were not given.

To summarize, while this article did indeed summarize what was synthesized from the already published literature, this article has a considerable amount of weaknesses as well as strengths that highlight the importance in conducting research, especially under the ethical, cultural, and diversity areas. It is important to consider the population as well as weaknesses and strengths so that a researcher can obtain the results him/her are aiming for.

Introduction

Research involving the human memory has been conducted for centuries now, the first human brain injury giving clues as to how the human memory works. Patient H.M.'s condition for Anterograde amnesia after his brain injury gave neuroscientist and researchers alike a lead to understanding just how the human memory works in encoding and storing information within the two memory systems, Short Term Memory and Long Term Memory. Craik [11] replicated Anne Treisman's Level of Analysis test to test the depth of each memory system and used multiple tests of his own creation to discover what it would take for the brain to encode certain information into the memory systems. The results of Criak's research along with the other researchers whom conducted research on the memory systems gave fruitful insight into how memories can be encoded into both short term and long term memory.

Brief Background

Memory encoding became a fundamental subject since the discovery of the limbic system, otherwise known as the emotional brain. The term limbic speaks of the subcortical structures that sit beneath the cerebrum that aids in forming memory based on the stimuli that enters through either the superior or inferior colliculus. Upon the discovery of this highly evolved area of the brain, particularly the memory forming areas such as the hippocampus and the Amaygdala, this system was later termed the limbic system as it was discovered that theses neuro- structures were able to process and encode memories based on sensation and/or emotional stimuli. The subcortical structures that are associated with the processing of emotional memories are the: Prefrontal Cortex, Amygdala, Anterior Cingluate Cortex, Hippocampus, and the Insula [5]. However, within these structures, the hippocampus and amygdala have been the most studied and were found to process emotional stimuli related to memory encoding thus processing and storing them in the long term memory system after leaving the working memory system [6,7].

To take emotional memory processing a bit more further, the journal article by William James (1884) entitled "What is an Emotion" brought into light one of the most thought provoking questions about emotions and how they can possibly be related to memory encoding. James proposed an innovative theory whereby human emotions occurred in response to afferent feedback loops from the sensory receptors in the skin, muscles, cartilage, and other organs which produced physical changes alongside the emotional experience.

Once the article came to light in the field, it gave birth to later experiments of the feedback loops of the sensory receptors in the body that traced these changes and were later discovered to assist in encoding information into memory storage to determine the exact quality of the stimuli experienced [5]. According to this same theory, emotions are just one form of experience of a wider array of physical changes that occur in response to emotional stimuli, also needed for human survival. James understood that different stimuli processes encoded different emotions as they entered through the brain through afferent nerve pathways. In contrast, a study of human emotions conducted by Walter Cannon, a Harvard physiologist, argued against James' theory of human emotions. Testing James' theory in a laboratory setting, Cannon concluded that human emotions, when provoked and studied in a lab setting, cannot be maintained in these states of arousal for further studies beyond being provoked. In comparison, the two studies of emotions by both researchers were valid in understanding how the emotions were linked to memory encoding. However, the hindrances in Cannon's studies were his artificial creation of emotions in the lab setting that could later be linked to encoding memories. Cannon failed to realize that emotions occur naturally and while occurring naturally, produce a natural reaction from the brain that will later encode the memory of what created such a reaction, a chunk of information that was left out of Cannon's theory of emotions and encoding. But without the creation of artificial emotions, what truly creates the memory encoding preceded by emotions?

The medial temporal lobe, which houses the hippocampus and amygdale specifically, became a central study in the event of brain damage that prevents the creation and encoding of memories. These findings pointed out the memory encoding is a distinct cerebral function, separate from the brain's other cognitive functions. After the study of H.M.'s encoding/memory defects, the name regarding this particular defect was later named Korsakoff's syndrome, after the Russian psychologist Sergi Korsakoff.

Methods and Materials

To further elaborate on the functions of the memory systems, emotional and stressful events connected to memory have been linked to information processing and encoding. The question was posed whether just emotional responses gained more influence in the memory than non-emotional responses. Dolcos & Cabeza [23] & Labar & Cabeza [24] states that emotional events are better remembered than unemotional events. Most studies have focused on the perception and evaluation of emotional stimuli and on the effects of emotion on memory formation. A critical distinction in the literature on emotional encoding is between two affective distinctions of emotional memory processing: emotional arousal and emotional valence. Arousal simply refers to a state that varies from calm to excitement, whereas valence simply refers to a state that varies from pleasant to unpleasant, with neutral as an intermediate distinctive value. Different approaches ranging from behavioral and pharmacological to electrophysiological and functional neuro-imaging have tried to define the anatomical and functional correlates of emotional processing and emotional memory.

Taking a closer look into what could possibly create an enhancing effect of emotion-memory correlation, Dolcos & Cabeza [23] gathered fifteen female right-handed university students from the Duke University. This particular sample was chosen due to the historical knowledge of women displaying more of a physiological response to most emotional stimuli than men. The sample was presented with a pool of 180 pictures that were chosen from the IAPS (International Affective Picture System) as pleasant, neutral, and unpleasant. Pictures were rated on a 9-point scale arousal scale with number one being the least arousing and nine being the most arousing. Another procedure called an Emotion Response Potiental (ERP) Recording cap was also used in conjunction with the picture pool during this study to record the physiological responses of the mastoid muscle in response to the stimuli presented. Ag/AgCl electrodes were embedded in the cap to give a read out of the muscle's response to the given stimuli. For this procedure, the reactions of the subjects were rated according to the 5 point scale of reaction with 1 being very unpleasant and 5 being very pleasant.

In a similar study by Payne, Jackson, & Hoscheidt [25] concerning stress and memory encoding, these authors found that stress profoundly influences memory in humans and other species. This is due to the of the hypothalamic–pituitary–adrenal axis, which releases stress hormones and assists in signaling the release of glucocorticoids (GCs) from the adrenal cortex. Many of the brain regions important for memory such as the hippocampus, prefrontal cortex, and the amygdala have dense concentrations of GC receptors and the function of these regions can be influenced by increased stress hormones [25]. Through their studies, they have found that stress and/or GC treatment can either impair or enhance memory performance, depending on several factors. One such factor is memory stage for example, encoding, consolidation, retrieval.

Glucocorticoids, interacting with adrenergic activation in the basolateral amygdale and the hippocampus appear to impair delayed memory retrieval, but enhance memory consolidation [25]. Although a better understanding of the impact of stress on memory consolidation and retrieval in humans is becoming clearer in the literature, it still remains unclear how stress is initiated prior to encoding than what affects later remembering. Nonetheless, examining the impact of stress on the long-term memory retention is important because it reflects how stress often operates in the real world. Stress can occur prior to or during encoding of an event that one may need to remember sometime later such as in the case of eyewitness testimony.

Conclusion

Through the many years of research concerning memory, there have been pit falls as well as victories in uncovering what memory truly is. As what was summed up and analyzed here, memory is not just one thing, but many things. However, what was specifically pointed out is that numerous functions such as biological functions of RNA and protein synthesis can help consolidate the memories via neuron plasticity (stability of the neurons so they care produce healthy firing of information/neurotransmitters) while the malfunction of certain biological functions like the Chromatins can contribute to forgetting or time decay of information/memories.

While some studies displayed better successful outcomes than others in the search for the elusive memory, the studies that displayed weak results in the search could have been stronger in the experiments and results segment of the research conducted. By doing so would have displayed a strength so that other researchers may replicate the experiment as such was done by Craik [11] in Treisman's Selective Attention study.

For future research conducted in the neuroscience field by future researchers, more research can be conducted about other areas of the brain that can possibly aide in the formation of memories and discrimination of stimuli from sensory and auditory entries into information to be encoded into the memory systems. While the research conducted in this article did point out important areas of the brain and body that aids in the encoding process such as stimuli that was discriminated from the superior and inferior colliculus, certain body regions such as the muscles, and certain biological functions such as the protein synthesis, more research can be aimed to understand what other segments of the brain plays in memory and information encoding.

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