ISSN: 2573-9565

Review Article

Journal of Clinical Review & Case Reports

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

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**Submitted**: 06 Nov 2018; **Accepted**: 12 Nov 2018; **Published**: 26 Nov 2018

## 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

## 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 [1]. Criak 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 calculus. 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 [2]. 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 [3,4].

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 [2]. 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, states that emotional events are better remembered than unemotional events [5,6]. 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, gathered fifteen female right-handed university students from the Duke University [5]. 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 Potiential (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 concerning stress and memory encoding, these authors found that stress profoundly influences memory in humans and other species [7]. 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 [7]. 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 [7]. 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 [8-15].

## Conclusions

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 [16-25].

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 Criak in Treisman's Selective Attention study [1].

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 [26-35].

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