Information Processing and Memory in Learning

Didi Nur Jamaludin
Institut Agama Islam Negeri Kudus
bioedu88@gmail.com

ABSTRACT
The success of learning is strongly influenced by information processing mechanisms and working memory. The characteristics of the initial information will affect the sensory response which is continued by storage in sensory memory. Various stimulus information such as psychophysical stimulus, emotional stimulus, discrepant stimulus, and manding stimulus will affect the response back from respondents. Information will be selected to enter short-term memory (STM) through a working memory mechanism with the ability to store information within a few seconds. Working memory is managed by the Central executive control center by involving the phonological Loop area, Episode buffer, and Visuospatial Sketch Pad. Then the information is continued to Long Term Memory (LTM) with repetition and coding mechanism. Long-term memory storage in the area of episodic memory, semantic memory, and procedural memory. Working memory is influenced by cognitive load (Cognitive Load) and Cognitive Fit Theory (CFT).

Abstract: Information Processing, Sensory Memory, Short Term Memory, Long Term Memory, Memory

ABSTRAK
INTRODUCTION

All the information that exists can not be separated from the information that someone did. When someone conveys information and provides instructions about the image, it will be carried out by the sensing system to proceed to the information for storage. Kross et al., (2020) explain that our ability to reach and remember information presented in the visual world is dependent on our short-term visuals (Visual Short Term Memory, VSTM).

The storage of information in memory has characteristics of working memory that can affect the storage of information. Someone can remember a large amount of information and some can store a small amount of information. Churchill & Elton, (2002) working memory is related to the cognitive psychology of language understanding. There are many barriers including a learner's ability to access information while learning a second language.

Memory is a key element in most cognitive processes (Solso, et al 2008). Studying the working memory system will support the storage system which needs to be discussed further, to strengthen the working memory to be able to be stored in long-term memory. The knowledge transfer process needs to pay attention to the memory mechanism so that the information obtained can be used again efficiently and effectively. The study of working memory is also interesting, sometimes someone feels satisfied when conveying a lot of information to students, even though students are not necessarily in a condition not or ready to receive information.

Priority and flexibility in attention also improve in the long term (Sandry et al., 2020). A teacher educator needs to pay attention to learning information in working memory to be understood and remembered easily. Various factors are prerequisites to receiving information easily in the short term (Short Term Memory, STM) and long term (Long Term Memory, LTM). The better a person in storing long-term memory, the better at constructing knowledge, so that it is more comprehensive.

So the task of the teacher or educator is only to convey information to students but can carry out an optimal learning process, taking into account knowledge of information, working memory, and factors that accelerate working memory. It is interesting to study further in this discussion, and at the same time, it can be used as reflective material on what has been learned and also what has been learned.
RESEARCH METHODS

This study uses a literature review in reviewing information processing with several sources of literature from journal articles and books. The research focuses on the theory of information processing and memory with a sub-study into 3 parts, namely Sensory Memory (SM), Short Term Memory (STM), and Working Memory (WM) and Long Term Memory (LTM).

RESULT AND DISCUSSION

Sensory Memory (SM)

A person receives information first by sensory memory such as from sight or hearing, then it will be stored through short-term sensory impression storage or Short Term Sensory Store (STSS) in a very short duration. Xie & Zaghloul, (2021) explained that the ability to observe will also affect the generalization of cognitive knowledge and the organization of working memory.

Results demonstrate that human Visual short-term memory (VSTM) simultaneously maintains representations at different levels of processing, from higher-order visual information to abstract semantic representations, which are stably maintained via coupling to hippocampal low-frequency activity. Here we combined human intracranial electroencephalography recordings with analyses using deep neural networks and semantic models to probe the representational format and temporal dynamics of information in VSTM (Liu et al, 2020).

Research conducted by Sperling simulates memory through the sensory system by paying attention to the following letters. Pay attention to the letters below in 1 minute, then remember later. Try to rewrite picture 1 on paper? How many letters are recognized?

<table>
<thead>
<tr>
<th>W</th>
<th>R</th>
<th>T</th>
<th>Z</th>
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</thead>
<tbody>
<tr>
<td>S</td>
<td>H</td>
<td>N</td>
<td>L</td>
</tr>
<tr>
<td>D</td>
<td>J</td>
<td>F</td>
<td>X</td>
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</table>

Figure 1. The display was used by Sperling (1960) and limits the central storage of sensory impressions.

Sperling (1960) explained that within 50 milliseconds, participants were asked to remember the first, second, and third letters. The results of the study respondents could
almost recall in one line perfectly. That is because the ability to recall after seeing all the letters, for a short time retains them in the center of the storage of sensory impressions.

Therefore, the important benefits of sensory memory in the cognitive system include (a) Students must pay attention to the information to be remembered. (b) The process of bringing information to consciousness requires decision-making time. (c) Information characteristics also affect storage speed. Easy material will certainly be easy to store, on the other hand, material complex materials have a good storage strategy and structure.

**Short Term Memory (STM) and Working Memory (WM)**

Information after getting short-term storage in sensory memory through the attention of the Short Term Sensory Store (STSS) will be processed into Short Term Memory (STM) with the ability to store information in a few seconds. Working Memory supports information processing work in the STM area. STM information can come from STSS and Long Term Memory (LTM). Information in STM is limited, if it is not considered it will be replaced by other information. Jonides et al., (2008) describe the process of storing information through encoding, rehearsal, maintenance, shifting from one attention to another, and retrieval mechanisms.

Gage and Berliner (1984) state that external stimuli are mostly able to evoke a person's response. The response is manifested through changes in body posture, brain waves, or other psychophysical responses. A person's response will determine whether to pay close attention or avoid it. Liu et al., (2020) This study addresses an important question regarding the interaction between visual short-term memory (VSTM) and prior knowledge stored as semantic memory and provides strong neural evidence for the close interaction between these two types of memory.

Figure 2. Information Schema in Short-Term Memory (STM) and Working Memory (WM). A revised model of (Bedeley, 2000)
Information after getting attention from memory will be continued in short-term memory through a working mechanism that is regulated by the Central executive control center involving the phonological loop area, Episode buffer, and Visuospatial Sketch Pad. Baddeley, (1992) explains that the central executive works like a supervisor or scheduler, the executor decides which issues are noteworthy and which are unknown.

The phonological loop storage area is related to a finite number of sounds if the material is not repeated. If there is information related to sounds such as language skills or knowledge related to conceptual rules. Meanwhile, the visuospatial Sketch Pad, related to storing visual and spatial information such as remembering the shape of a space or seeing certain images, is part of the storage in this area.

Both parts are associated with episode buffers which are used for the temporary storage of information or between language information (Phonological Loop) and visual and spatial information will be associated with episode buffers. This can easily happen when someone sees news information on a volcanic eruption disaster on television, it will store information in the form of the scene and the atmosphere of the physical condition of the house and community affected by the disaster. This information can be stored in short-term memory or can be stored in long-term memory.

Representations in short-term memory consist of a collection of features for stored information, including features that represent the context in which the information was found. Representations in memory vary inactivation, with the character of the inactive state constituting the long term, and various states of activation due to recent perception or retrieval of the representation. Information items can enter the focus of attention through perceptual coding or retrieval based on Long Term Memory. Items are maintained in focus through a controlled maintenance process, with the practice being allocation cases, controlled from the focus of attention. There is a focus of attention in which a collection of information can be made in a state that is immediately available for cognitive action. Attention can be defined only on one piece of information at a time, where the piece draws a set of items that are adapted to a common functional context (Jonides, et al 2008).

Based on Figure 2, it shows that the attention of sensory memory will affect the storage of information towards short-term memory, here are the differences between the two it.
Table 1. Differences between Sensory Memory and Short Term Memory

<table>
<thead>
<tr>
<th>No.</th>
<th>Sensory Memory (SM)</th>
<th>Short Term Memory (STM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Withhold information for 2 seconds or less.</td>
<td>Withhold information for about 30 seconds.</td>
</tr>
<tr>
<td>2</td>
<td>Information is still relatively raw and unprocessed.</td>
<td>Information has been manipulated by comparing information.</td>
</tr>
<tr>
<td>3</td>
<td>Information is more accurate in describing the stimulus.</td>
<td>Information is more likely to change and be inaccurate.</td>
</tr>
<tr>
<td>4</td>
<td>Information is registered passively.</td>
<td>Information is actively selected.</td>
</tr>
</tbody>
</table>

Quilez-Robres et al., (2021) describe factors that influence short-term storage, namely intelligence quotient (IQ) and study habits, both of which are predictive factors for almost 60%, and although short-term memory is associated with knowledge, it is not a factor, significant in predicting academic achievement in elementary school children. These results have remained stable for two consecutive years in primary school students. When a child has low academic achievement, it is necessary to conduct a psycho-pedagogical evaluation. The results show us that IQ and study habits can be good predictors of academic performance, so they should be evaluated preferentially.

The stimulus has an important role in storing information in short-term memory. Anni et al, 2006 describe several types of stimulus variations that need to be considered in order to make information pay attention, so that information stored in sensory memory can be further processed in short-term memory.

1. Psychophysical stimulation
   Variations in sound intensity and color can elicit certain responses. What is the impression of being taught by a teacher who has a firm and low voice? The stimulus certainly gives the impression that someone is different, it can be a firm or low voice giving a warning meaning. The main thing is to make the psychophysical stimulus something interesting for students.

2. Emotional stimulation
   Emotional stimulus (soul/feeling) capable of evoking a certain response. What is the impression of a teacher who has made you concerned/worried/optimistic/smiling/sad?
3. Discrepant stimulus (stimulus gap)
   The stimulus can arouse attention because of the effect of novelty, complexity, and uniqueness. Teachers or educators need to convey at the beginning that the information provided provides an interesting uniqueness or something that is important to learn.

4. Manding stimulus
   Manding is a verbal stimulus that has high consequences, like look at this picture… try to explain the meaning?. The stimulus is so that students can become stronger reminders.

   Jonides, J. et al, (2008) explained that short-term memory has the following information characteristics.
   1) Memory representations vary through inactivation, which is formed through the perception or retrieval of new information.
   2) There is a focus of attention where the collection of information relates to cognitive actions.
   3) Attention is limited to one piece of information at a time.
   4) Items can enter the focus of attention through perceptual coding or retrieval from the LTM.
   5) Items are maintained in focus through a controlled maintenance process, with controlled practice with focused attention.
   6) Forgetting occurs when an item leaves the focus of attention and has to compete with other items or when representational attention decreases over time due to a stochastic (decay) process.

   The application of short-term memory and working memory in learning activities is as follows.
   a. Teachers need to give children opportunities for rehearsal to maintain STM and move to LTM.
   b. Teachers should not provide large amounts of information, it needs an area of attention because of the limitations of STM.
   c. Some of the information that comes in from the STM can come from short-term sensory storage (STSS) or long-term memory (LTM).

Long Term Memory (LTM)

   Information after being temporarily stored in sensory memory and short-term memory, if selected for repetition and encoding will be continued in long-term memory.
Storage in the long-term memory area has a longer storage power than in the short-term memory area. This rule makes information sometimes attached to be remembered, often information is sometimes forgotten.

Not all of the information observed by the sensory system will be selected for inclusion in short-term memory. For example, when someone observes various writings leading to the school area, maybe only a few are selected to be remembered to be included in short-term memory, the rest of the writing on the side of the road is not the main concern. If the writing becomes the main concern, it will become long storage, usually related to writing that is iconic in a certain area.

![Figure 2: Information schema on sensory memory, working memory, and long-term memory (Jan Claes, Frederik Gailly, and Geert Poels, 2013)](image)

The results show that there are efforts to control how LTM content is selected to enter WM. In addition, the data suggest that a single gate and co-attention selection mechanism likely controls access to WM for perceptual and LTM sources. These findings suggest that the WM model relates to various sources of information input (Verschooren et al., 2021). This shows that the mechanism of long-term memory is related to the working memory system.

Long-term memory theory is grouped into three parts (Gage and Berliner 1984, Slavin, 1994), including episodic memory, semantic memory, and procedural memory, namely:

a) Episodic memory

The memory of mental images seen and heard, images can be analogous to physical representations. Examples of modeling cell organelles such as mitochondria, nucleus, and endoplasmic reticulum.

b) Semantic memory (semantic memory)

Semantic memory about generalized facts, concepts, principles, and theories.
Semantic memory is also known as declarative memory which can be organized by the schema. Examples of recognizing the various functions of cell organelles such as mitochondria, nucleus and endoplasmic reticulum.

c) Procedural memory (procedural memory)
Memory about how to do something, especially in physical tasks, or related to procedural knowledge such as observed using a microscope.

![Figure 3. Information Schema in Long Term Memory (LTM)](https://articles.jebhealth.com/2017/12/15/science-behind-muscle-memory/long-term-memory/)

Semantic and episodic information revealed that there was more activity for the semantic dimension at all grade levels. Most of the activities in the semantic dimension, which include academic knowledge and skills, are aimed at lower-order thinking skills; In the episodic dimension, the highest number of activities is designed at the level of creating while the lowest number of activities is intended for the level of analysis and evaluation at all grade levels (Uğur, 2019).

The working memory process is also influenced by the cognitive load of information. Sweller (1998) explains that the efficiency of our working memory usage is determined by the cognitive load in performing a task.

1) Intrinsic cognitive load that is, the amount of information needed to perform a task, depends on the task,
2) Extraneous cognitive load is the amount of information required to interpret the input, depending on the data representation of the task, and
3) Germane cognitive load that is, the amount of remaining information that the subject needs to load in working memory to perform the task, mainly depends on the subject's expertise.
Cognitive Load Theory (CLT) shows that the number of errors increases when capacity is limited, and our working memory is overloaded. Cognitive Fit Theory (CFT) states that performance increases when the representation of task material matches the task to be executed (Claes, Gailly, and Poels, 2014). Therefore, in processing information when it enters long-term memory, information can be selected to be selected and organized so that it can be stored in long-term memory.

Cognitive Fit Theory (CFT) states that when the representation of task material is by the task to be carried out, people tend to be more effective and efficient in carrying out the task. For example, tabular data representations are said to be more suitable for solving questions that ask about facts, and graphical representations are better suited for questions about in-depth information derived from data (Vessey, I., Galletta, D, 1991).

Other things that affect long-term memory include the following.

1. Information Processing Level
Craik and Lockhart (1972) explain that the deeper the processing level, the better the recall process. Effect of Self-Reference You will remember some information if you relate that information to yourself. In deep processing, there are two factors, namely:
   a. Distinctiveness means that the stimulus is different from other memories. So to store information in long-term memory, it is better if the information can be distinguished, for example, the difference in the definition of diffusion and osmosis.
   b. Elaboration requires more processing in determining the meaning and relevance of concepts (Craik, 1999, Smith, 2006). Examples of elaboration activities include linking the rules of diffusion and osmosis in cellular transport, the circulatory system, and the digestive system.

Information processing is influenced by a person's self-reference, so the factors that influence self-reference are as follows.
   a. Self makes a special set of signs. You can easily associate a special sign with the new information being studied, this particular sign also includes its distinctiveness (Belleza & Hoyt, 1992).
   b. Self-reference instructions encourage people to think about how personal characteristics relate to others (Burns, 2006).
   c. You repeat the object more often if it relates to yourself. You also use object repetition when associated with yourself (Thompson, 2005). The repetition strategy can make it easier to remember (recall).
The integration of the power of Motivation and the structure of Long-Term Memory in the cognitive architecture provides a progressive development toward the representation of a complete information model (Antonio Becerra et al., 2021). The ability to elaborate (connect) through sentences, and additional instructions to form mental images, benefits working memory. Older adults do not benefit from the elaboration demonstrated by the delayed test, providing further evidence that older adults' long-term memory deficits arise at least in part from deficits in elaboration (Bartsch & Oberauer, 2021).

2. Effect of Context on Coding Specificity

The process of remembering in long-term memory often gives impressions in certain codes. This coding will be a stimulus to be able to store in long-term memory. The coding can be made specifically, by making special abbreviations, and acronyms or by cutting information or grouping it, such as remembering the HP number 0857-2796-5740.

When many phenomena are thought to require dedicated short-term memory it can be explained through an integrated theory of episodic and semantic memory. This suggests that an integrated theory of long-term memory must be added to explain this extraordinary memory phenomenon. The process cannot be separated from a special mnemonic system, a sensor-based system or language, or, also in other words having mnemonic abilities (Humphreys et al., 2020). So coding such as abbreviations, acronyms, and cutting sentences becomes a way to explain the phenomenon of someone being able to store large amounts of information.

3. Emotions, Moods, and Memories

Cognitive psychologists state that emotions and moods can affect our cognitive processes. A person remembers more accurately with a pleasant stimulus than with other stimuli, he or she can also recall material more accurately if our mood matches the character of the material, this effect is called mood congruence. A person who likes to remember more pleasant material than unpleasant material

Studies on the difference between short-term and long-term memory, have shown to be related to protein synthesis, here are the:

<table>
<thead>
<tr>
<th>No</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remembers information within seconds to hours.</td>
</tr>
</tbody>
</table>

Table 2. differences between Short Term Memory (STM) dan Long Term Memory (LTM)
<table>
<thead>
<tr>
<th></th>
<th>Information is labile (sensitive to damage)</th>
<th>Information is stable (resistant to damage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Does not require new RNA or protein synthesis</td>
<td>Require new RNA or protein synthesis</td>
</tr>
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</table>

Someone in information processing sometimes there is someone who remembers someone who forgets or does not remember something. This can be related to information processing, some of the causes are as follows.
1) Information from short-term memory is never transferred to long-term memory, such as repetition, coding, and organizing of information,
2) The interference factor is information mixed with other information.
3) Retroactive interference, if the information obtained, interferes with learning the next information, for example, le the initial material has difficulty, then the material to be studied becomes an obstacle.
4) Proactive interference; if the information obtained interferes with studying the previous information, for example, someone learns about osmosis material about the movement of water, while the previous study tells about the osmosis of the transfer of solvents.
Definitions that have not found common ground, can often lead to forgetfulness.

Based on information processing and working memory, we can determine several strategies that can be applied in learning, as follows.
1. Using various psychophysical, emotional, and discrepant stimuli such as the use of various voices in delivering the material, expressions with smiles and happiness, or even warnings if needed as well as the up-to-date and usefulness of teaching materials.
2. The attention to essential materials
3. Doing coding by using abbreviations or parables (analogy).
4. Using Cognitive Load Theory (CLT) to describe knowledge of concepts, and principles that cause working memory to become overloaded, by providing easy-to-understand definitions.
5. Using the rules of Cognitive Fit Theory (CFT) to create a framework for the tasks to be carried out, to facilitate working memory.

CONCLUSION

Information processing occurs through sensory stimuli through storage in sensory memory, then will be selected to enter Short Term Memory (STM) through the mechanism
of Working Memory with the ability to store information in a few seconds. Working memory is managed with the Central executive control center by involving the phonological Loop area, Episode buffer, and Visuospatial Sketch Pad. Then the information is continued to long-term memory (LTM) with repetition and coding mechanism. Storage of long-term memory in the area of episodic memory, semantic memory, and procedural memory. Working memory is affected by cognitive load theory and cognitive fit theory.

REFERENCES


