Learning and Memory

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Lesson Objectives:

By the end of this workshop, teachers should be able to:

- Define the different types of memory and the processes underlying memory formation
- Discuss the role of the hippocampus in memory formation using examples from amnesia patients
- Demonstrate a basic understanding of the neural substrates of learning and memory
- Understand the six learning strategies and how to implement them in the classroom

Different Types of Memory

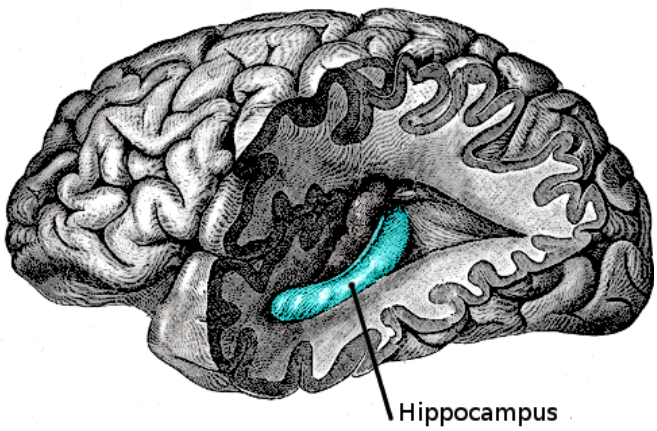
The first thing that may come to mind when you hear the word "memory" is the ability to memorize information: important dates, vocabulary words, multiplication tables, and so on. In reality there are many different types of memory. Memory can be separated into **working memory**, which is the ability to hold information in the mind temporarily (e.g., mentally rehearsing a telephone number until you are able to write it down) and longer-term forms of memory. **Declarative memory** refers to memories that can be knowingly recalled, and can be further divided into two categories: semantic and episodic. **Semantic memory** denotes memories for concepts or facts, while **episodic memory** denotes memories for experienced events. In addition, **procedural memory** refers to memory for learned skills (e.g., riding a bike).

Memory Processes

Memory consists of three distinct processes: encoding, storage, and retrieval. **Encoding** is the accumulation of new information. **Storage**, also called **memory consolidation**, is the process through which memories are transferred from short-term to long-term storage. Finally, **retrieval** is the recollection of stored information.

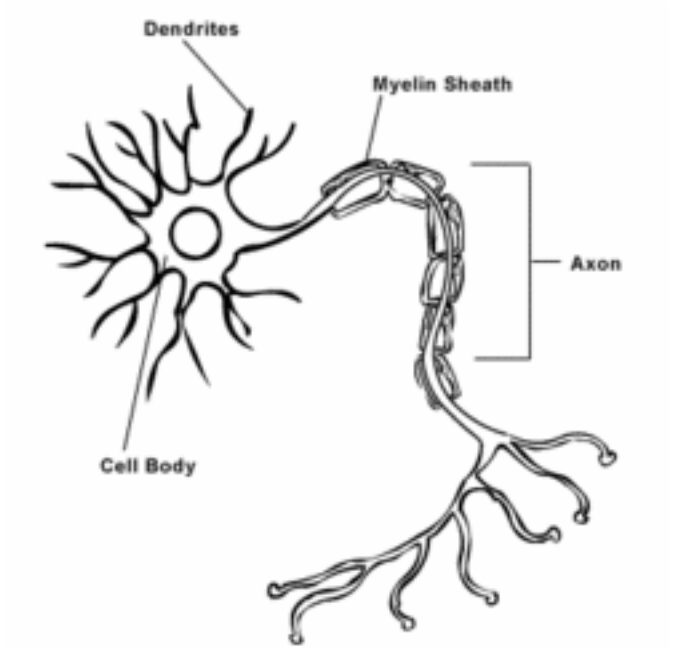
Where Are Memories Stored?

Much of what we know about the various parts of the brain that support memory processes originated from the well-documented case of Henry Molaison (often referred to simply as HM). HM suffered from severe epilepsy, and he underwent brain surgery in order to relieve his severe seizures. Surgeons removed the brain regions where his seizures were originating: the **medial temporal lobe** and **hippocampus** on each side of HM's brain. While the procedure helped to alleviate HM's seizures, it also resulted in his inability to form new declarative memories, a condition called **anterograde amnesia**. He also demonstrated symptoms of **retrograde amnesia**, as he was unable to retrieve memories of his recent past. However, further investigation revealed that HM was still capable of learning new skills and holding information in his mind for short periods of time, proving that his procedural and working memory remained in tact. This indicated that the medial temporal lobe and hippocampus are necessary specifically to support formation and utilization of long-term declarative memories. Subsequent research, including other notable amnesia cases, have provided further evidence that these brain regions, as well as connected structures (e.g., structures that make up the **Papez circuit**), are indeed necessary for formation, storage, and retrieval of declarative memories.



How Are Memories Stored?

Our brain cells, or **neurons**, are made up of three distinct parts: the dendrites, soma, and axon. The **dendrites** are highly branched processes that receive signals from other neurons. The signal is transferred to the cell body, or **soma**. If the signal is strong enough, it can be propagated along the **axon**, where the signal will spread to other neurons by crossing synapses. **Synapses** are small gaps where the axon of one neuron contacts the dendrites of another neuron. More specifically, axons contact dendrites at small membranous protrusions called **dendritic spines**.



Neurons can receive many kinds of information from other neurons. They can make **associations** by receiving signals at multiple synapses simultaneously. For example, a neuron might encode for pepperoni pizza if it receives information from neurons encoding crust, cheese, sauce, and pepperoni. Synapses between neurons are highly plastic; they can become stronger or weaker with experience. This means that neurons can learn to make associations based on real-life events. This phenomenon is called **synaptic plasticity**, and it is thought to be the neural substrate underlying learning and memory.

Activity Summary

There are many cognitive memory tasks that can be implemented in the classroom to demonstrate the labile nature of memory, including the **Deese-Roediger-McDermott Paradigm** (DRM), and the **"War of the Ghosts"** story.

The DRM is used to study **false memories**. It consists of reading a simple word list containing several related words (see DRM word lists below) aloud after instructing students to do their best to remember the words on the list. After a short break during which students are ideally engaged in some kind of distracting task, the instructor reads a second word list containing a **critical lure**. The critical lure is a word that is unrepresented on the original word list, though it is commonly associated with each word on that list. As the instructor reads the second word list, students should indicate whether or not they recognize each word from the first list. Typically, many of the students will report that they remember the critical lure from the original list, illustrating the ease with which false memories can be formed. This phenomenon

can potentially be explained by the fact that we often remember associated words even when they are not presented, demonstrating that past experiences can have a profound impact on memory formation at a subconscious level.

The "War of the Ghosts" is a story that psychologist **Frederic Bartlett**, a forerunner in cognitive memory research, used to study memory as early as 1932. To implement this classic memory task in the classroom, read "War of the Ghosts" aloud as students read along. Instruct students to do their best to hold on to the passage mentally. At a later time, ask students to reproduce the story in writing, including as many details as they can remember. The task is most effective if students reproduce the story at multiple time points. Then, ask students to compare their versions of the story to the original version. As students recall the story at increasingly delayed time points, they will tend to omit details, use increasingly vague language, and even forget entire sections. Perhaps most interesting, students will likely transform elements of the story to align better with their own preconceived ideas about the world (e.g., remember "canoe" as "boat"). This activity is ideal to demonstrate the dynamic nature of memory and how memories can change more and more over time.

Activities: Deese-Roediger-McDermott Paradigm (DRM) and "War of the Ghosts" Story

Materials needed:

- DRM word lists
- "War of the Ghosts" Story
- Paper and writing utensils

The purpose of these activities is to show that *memory is not stable*. The brain can be easily manipulated to encode false memories, and memory changes significantly over time. The DRM paradigm takes around 10 minutes, and the "War of the Ghosts" activity can take anywhere from an hour to days, depending on the retention interval. It is best to test memory for the "War of the Ghosts" story at several time points for comparison.

Deese-Roediger-McDermott Word Lists

Word list 1: Butter, Food, Eat, Sandwich, Lunch, Milk, Jelly, Crust, Slice, Toast
Critical Lure: *BREAD*

Word list 2: Candy, Bake, Sugar, Taste, Tooth, Honey, Chocolate, Good, Cake, Pie
Critical Lure: *SWEET*

Word list 3: Bed, Rest, Tired, Dream, Night, Blanket, Snore, Nap, Peace, Yawn
Critical Lure: *SLEEP*

Word List #4: Table, Sit, Legs, Seat, Desk, Wood, Cushion, Hard, Rocking, Bench
Critical Lure: *CHAIR*

For the second word list, generate a list of words that contains the critical lure!

The "War of the Ghosts"

One night two young men from Egulac went down to the river to hunt seals, and while they were there it became foggy and calm. Then they heard war-cries, and they thought: "Maybe this is a war-party". They escaped to the shore, and hid behind a log. Now canoes came up, and they heard the noise of paddles, and saw one canoe coming up to them. There were five men in the canoe, and they said:
"What do you think? We wish to take you along. We are going up the river to make war on the people".
One of the young men said: "I have no arrows".
"Arrows are in the canoe", they said.
"I will not go along. I might be killed. My relatives do not know where I have gone. But you", he said, turning to the other, "may go with them." So one of the young men went, but the other returned home.
And the warriors went on up the river to a town on the other side of Kalama. The people came down to the water, and they began to fight, and many were killed. But presently the young man heard one of the warriors say: "Quick, let us go home, that man has been hit".
Now he thought: "Oh, they are ghosts". He did not feel sick, but they said he had been shot.
So the canoes went back to Egulac, and the young man went ashore to his house, and made a fire. And he told everybody and said: " Behold I accompanied the ghosts, and we went to fight. Many of our fellows were killed, and many of those who attacked us were killed. They said I was hit, and I did not feel sick".
He told it all, and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried. He was dead.

Six Learning Strategies:

1. The testing effect

The testing effect is the finding that encoding is much more successful when information is generated through self-testing or prompted testing versus rote repetition. For example, simply rehearsing to-be-retrieved information repeatedly is not nearly as important as periodically retrieving answers when cued with a question. *Practical example*: Single-sided versus double-sided flashcards – If a student cues memory with an answer on one side of a flashcard, generates the answer without looking, then reviews the correct answer by flipping the card over, this results in statistically significantly higher gains in learning.

2. Spacing effects (distributed practice)

Spacing learning out over time allows for increased memory consolidation. This is the opposite of massed repetition over a brief period of time, which leaves minimal time for memory consolidation and promotes learning on a superficial (and less optimal) level. *Practical example:* Short study sessions over the course of one month leading up to a mid-term exam versus cramming during days (or even hours) before the exam. Although cramming cannot always be avoided, it increases anxiety, which is harmful to memory, and it results in poorer retrieval.

3. Levels of processing

One of the oldest and most powerful tools from experimental cognitive psychology, the levels of processing effect is the observation that the depth with which you encode information directly affects learning and memory. Shallow encoding, such as simply re-reading text, is much less effective than encoding information on a deep conceptual level. *Practical example:* Highlighting text, especially in middle school and high school, can actually have a harmful effect on learning. Highlighting *feels* good, and it establishes a cognitive illusion of having learned information on a deep level, thus a student may ignore highlighted information that has in reality been encoded very superficially.

4. Interleaved learning

When learning information from multiple categories, it is beneficial to mix exemplars from multiple categories into one learning session versus learning discrete categories in blocked fashion (e.g., learning XXX YYY ZZZ is less beneficial than learning XYZ XYZ XYZ). *Practical example:* Although it takes a bit of work up front, organizing lesson plans in an interleaved manner is far better for students in the long run. Again, this strategy may not always be practical with topics that must be taught in modules, but even relating present concepts to past concepts is one form of interleaving.

5. Metamemory Calibration

Metamemory is one's own knowledge and confidence about their own memory performance. The degree to which judgments about learned information accurately reflects real memory performance is called calibration. Students can become miscalibrated over time, and often demonstrate overconfidence (i.e., they believe they are learning effectively when they are not). *Practical example:* Frequent quizzing (even if the quizzes are not graded) allows a chance for calibration and adjustment of study time/strategies as well as seeking outside help. One simple classroom application is asking students to predict exam performance prior to testing, having them estimate performance after testing, and then asking them to compare their estimated performance to actual performance.

6. Multimedia-Learning

Directly related to levels of processing, learning information is an active process that involves multiple sensory modalities with limited capacity. Balancing the use of each modality (e.g., visualizations combined with text, online discussion, hands-on demos) results in deeper encoding, higher quality consolidation, and improved retrieval over time. Multimedia learning is also an important way for educators to embrace the technology that students are becoming so proficient at. *Practical example:* The use of in-class response systems, such as e-clickers, is increasing in popularity. This allows for interaction with multiple students using technology and visualizations. Visit www.adaptedmind.com for some great examples of online learning tools that incorporate multimedia-learning theory into lessons for multiple ages.