Memory Consolidation

http://www.human-memory.net/processes_consolidation.html

Consolidation is the processes of **stabilizing a memory trace after the initial acquisition**. It may perhaps be thought of part of the process of encoding or of storage, or it may be considered as a memory process in its own right. It is usually considered to consist of **two specific processes**, **synaptic consolidation** (which occurs within the first few hours after learning or encoding) and **system consolidation** (where hippocampus-dependent memories become independent of the hippocampus over a period of weeks to years).

Neurologically, the process of **consolidation utilizes** a phenomenon called **long-term potentiation**, which allows a synapse to increase in strength as increasing numbers of signals are transmitted between the two neurons. **Potentiation** is the process by which synchronous firing of neurons makes those neurons more inclined to fire together in the future. Long-term potentiation occurs when the same group of neurons **fire together so often that they become permanently sensitized to each other.** As new experiences accumulate, the brain creates more and more connections and pathways, and may **"re-wire"** itself by re-routing connections and re-arranging its organization.

As such a neuronal pathway, or **neural network**, is traversed over and over again, an enduring pattern is engraved and neural messages are more likely to flow along such familiar paths of least resistance. This process is **achieved by the production of new proteins** to rebuild the synapses in the new shape, without which the memory remains fragile and easily eroded with time. For example, if a piece of music is played over and over, the repeated firing of certain synapses in a certain order in your brain makes it easier to repeat this firing later on, with the result that the musician becomes better at playing the music, and can play it faster, with fewer mistakes.

In this way, the brain organizes and reorganizes itself in response to experiences, **creating new memories prompted by experience, education or training.** The ability of the connection, or synapse, between two neurons to change in strength, and for lasting changes to occur in the efficiency of synaptic transmission, is known as **synaptic plasticity** or **neural plasticity**, and it is one of the important **neurochemical foundations of memory and learning**.

It should be remembered that each neuron makes thousands of connections with other neurons, and memories and neural connections are mutually interconnected in extremely complex ways. Unlike the functioning of a computer, each memory is embedded in many connections, and each connection is involved in several memories. Thus, multiple memories may be encoded within a single neural network, by different patterns of synaptic connections. Conversely, a single memory may involve simultaneously activating several different groups of neurons in completely different parts of the brain.

The inverse of long-term potentiation, known as **long-term depression**, can also take place, whereby the neural networks involved in erroneous movements are **inhibited** by the silencing of their synaptic connections. This can occur in the **cerebellum**, which is located towards the back of the brain, in order to correct our motor procedures when learning how to perform a task (procedural memory), but also in the synapses of the **cortex**, the **hippocampus**, the **striatum** and other memory-related structures.

Contrary to long-term potentiation, which is triggered by **high-frequency** stimulation of the synapses, long-term depression is produced by nerve impulses reaching the synapses at very **low frequencies**, leading them to undergo the reverse transformation from long-term potentiation, and, instead of becoming more efficient, **the synaptic connections are weakened.** It is still not

clear whether long-term depression contributes directly to the storage of memories in some way, or whether it simply makes us **forget** the traces of some things learned long ago so that new things can be learned.

Sleep (particularly **slow-wave**, or **deep**, sleep, during the first few hours) is also thought to be **important in improving the consolidation of information in memory**, and activation patterns in the sleeping brain, which mirror those recorded during the learning of tasks from the previous day, suggest that new memories may be solidified through such **reactivation** and **rehearsal**.

Memory **re-consolidation** is the **process of previously consolidated memories being recalled and then actively consolidated all over again,** in order to maintain, strengthen and modify memories that are already stored in the long-term memory. Several retrievals of memory (either naturally through **reflection**, or through deliberate recall) may be needed for long-term memories to last for many years, depending on the **depth** of the initial processing. However, these individual retrievals can take place at increasing intervals, in accordance with the principle of **spaced repetition** (this is familiar to us in the way that "cramming" the night before an exam is not as effective as studying at intervals over a much longer span of time).

The very **act of re-consolidation**, though, may **change the intial memory**. As a particular memory trace is reactivated, the strengths of the neural connections may change, the memory may become associated with new emotional or environmental conditions or subsequently acquired knowledge, expectations rather than actual events may become incorporated into the memory, etc.

Research into a cognitive disorder known as Korsakoff's syndrome shows that the retrograde amnesia of sufferers follows a distinct **temporal curve**, in that the more remote the event in the past, the better it is preserved. This **suggests that the more recent memories are not fully consolidated and therefore more vulnerable to loss**, indicating that the process of consolidation may continue for much longer than initially thought, perhaps for **many years**.

??? Did You Know ???

Studies have shown that we often construct our memories **after the fact**, and that we are susceptible to **suggestions** from others that help us fill in the gaps in our memories.
This **malleability of memory** is why, for example, a police officer investigating a crime should not show a picture of a single individual to a victim and ask if the victim recognizes the assailant.
If the victim is then presented with a line-up and picks out the individual whose picture the victim had been shown, there is no real way of knowing whether the victim is actually remembering the assailant or just the picture.

??? Did You Know ???

Reading out loud (or even whispering or mouthing it) forms **auditory links** in our memory pathways, as well as visual ones from looking at a page or screen. So, we remember ourselves producing and saying the information as well as reading it visually, which may improve our overall retrieval of memories. But this process works best, when just SOME of the information (e.g. the most important words or concepts) is read out loud, and the rest not, as this takes advantage of the **"oddball effect"** whereby we remember the more unusual or distinctive information best.

??? Did You Know ???

Studies have shown that information is **transferred between the hippocampus and the cerebral cortex during deep sleep**, and **sleep appears to be essential for the proper consolidation of long-term memories.** However, even **daytime naps** can help improve memory to some extent, and helps with the memorization of important facts.