The Process of Forming a Memory

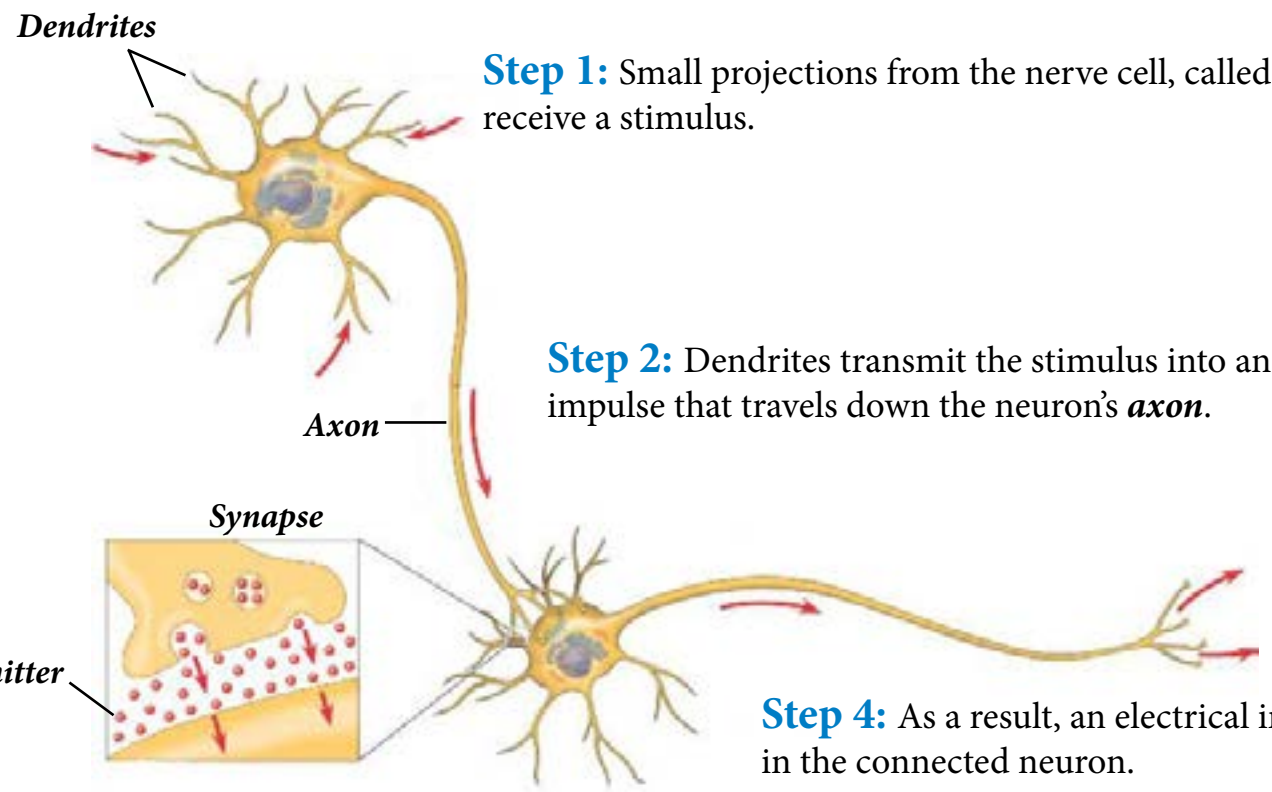
Overview

Memory is the process of encoding, storing, and retrieving information. It provides a source of knowledge, but is also a fundamental aspect of a person's identity. Although the micro-level mechanisms of memory formation are not completely understood, there are widely-accepted stages involved in the creation of memories: sensory memory, short-term memory, and long term memory [1]. This document will explain each stage in detail to demonstrate the process of embedding a memory into the brain.

Scientific Background

To encode a memory, information is first registered by the senses. Within the brain, this sensory information is transmitted and stored using electrical and chemical signals. These electrochemical signals are transmitted from neuron to neuron across synapses – junctions between two nerve cells. This complex process can be simplified into a series of four steps, as described below in Figure 1 [2]:

Figure 1: *Neural Communication*



Step 1: Small projections from the nerve cell, called ***dendrites***, receive a stimulus.

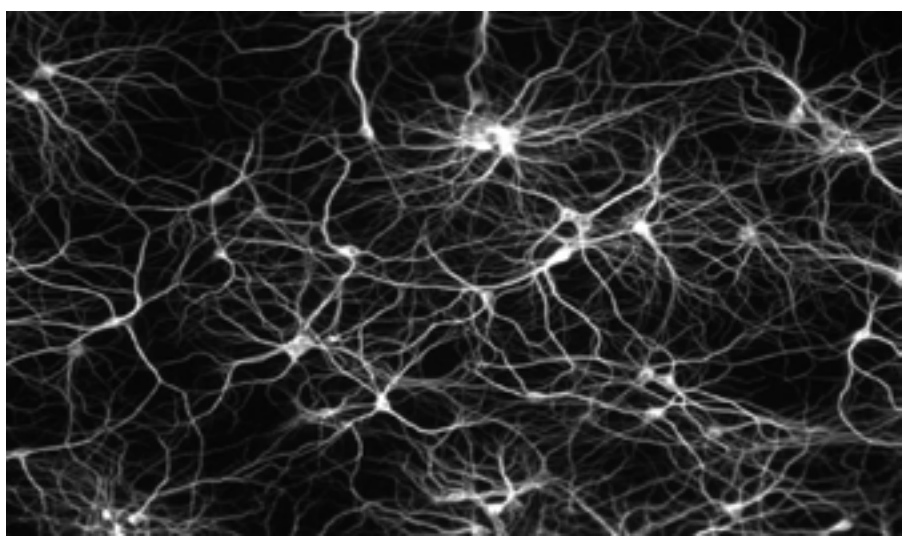
Step 2: Dendrites transmit the stimulus into an electrical impulse that travels down the neuron's ***axon***.

Step 3: The electrical impulse reaches the ***synapse***, which causes chemical messengers, or ***neurotransmitters***, to be released. The neurotransmitters diffuse across the synaptic junction.

Step 4: As a result, an electrical impulse is initiated in the connected neuron.

Each brain cell can form thousands of these connections, resulting in about 100 trillion synapses in a typical brain. The image to left, Figure 2, illustrates just a percentage of these synaptic junctions. These connections are not stationary; in fact, they change all the time. With repeated use, connections can grow stronger and faster, permitting a quicker recollection of a memory [3]. However, these connections can also degrade or be lost altogether. This concept of neural communication is the basis of encoding, storing, and recalling a memory.

Figure 2: *Neural Connections*



Stages of Memory

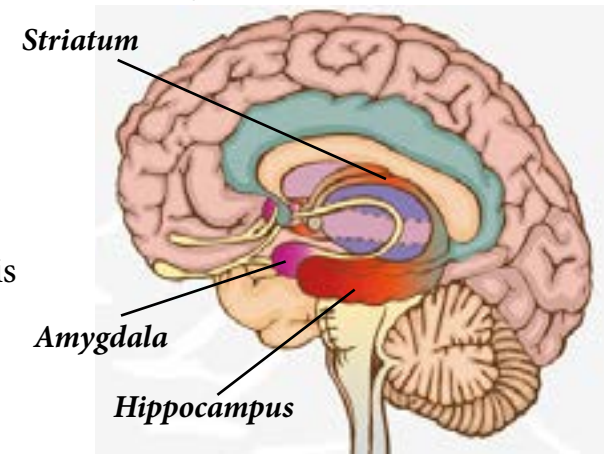
Once neurons in the brain recognize an external stimulus, they must process the information and store it as a memory. Initially, the information is interpreted in sensory memory. If the information is integrated into conscious awareness, it can be transferred to short-term memory. Finally, short-term memories can be committed to long-term memory through repetition. This process is further described in the diagram below.

Information from the environment

Sensory Memory

- Combines tastes, smells, sounds, sights, and touches to produce a single perception
- Lasts for fractions of a second
- Utilizes the hippocampus, illustrated in Figure 3, to determine which sensory messages get encoded [4]
- Has a very limited capacity, as most of what is sensed is almost immediately forgotten [3]
- Requires selective attention to transfer information to short-term memory [1]

Figure 3: *Brain Structures*



Forgotten

Transferred

Short-Term Memory

- Has a fairly limited capacity and only stores memories temporarily
- Can typically hold about 7 items for up to 30 seconds
- Is improved through a memory strategy called chunking. Chunking is the process of grouping information into units that are easier to remember. For example: 8005926875 may be too long for short-term memory, but if it is grouped into chunks, as in a telephone number 800-592-6875, it is easier to remember [3].
- Requires the rehearsal of information in order for it to be committed to long-term memory; the more information is repeated or used, the more likely it is to be retained [3]. Repetitive learning is the most common way for memories to be transferred to long-term memory [1].

Rehearsed

Forgotten

Transferred

Retrieval

Long-Term Memory

- Can store unlimited amounts of information for an indefinite time
- Commitment is more likely if the material is related to previously-learned information [5]
- Is a brain-wide process that incorporates many regions of the brain to store and recall a single memory [3]. Scientists describe memory as taking a photograph, cutting it into numerous small pieces, and storing them in different files.
- Requires numerous brain structures to function. For instance, the striatum is involved with memories for skills and habits, the hippocampus is involved with memories for facts and events, and the amygdala is involved with emotional memories [5]. These structures are indicated in Figure 3 [4].

Conclusion

Forming a memory is a complex process involving three important phases of memory storage. By understanding these stages, scientists can propose methods of enhancing memory storage and study the difficulties associated with memory loss.

References

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