NEUR0010: Learning and Memory Part 1
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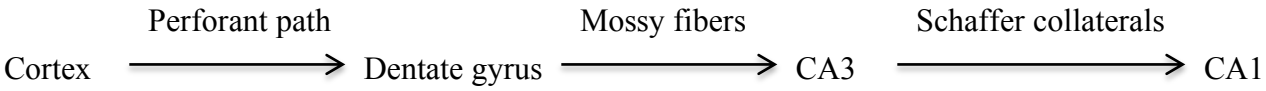
Comparing and contrasting different "types" of memory

	Working memory	Short-term memory	Long-term memory
Description	Used to keep things "in mind," very labile (changeable)	Holding information in a readily available state for short time	Holding information in an available state for a long time
Capacity	Small (limited)	Large	Large (basically infinite)
Timeframe	Seconds	Minutes to hours	Hours to years
Brain area responsible	Frontal cortex	Hippocampus	Cerebral cortex

Key facts about memory and recognition

- Area IT in the dorsal stream of the visual pathway can recognize and gain selectivity for faces.
- The formation of a memory can involve *either* synaptic strengthening or weakening. (it's not always strengthening!)
- Memory is a distributed code – that is, it is stored in the patterns of neural communication, not just in one neuron itself.

The hippocampal pathway of information flow



Mechanisms of LTP (Long-term potentiation)

LTP refers to the modification of synapses that allow them to get stronger. The mechanism of this is as follows:

1. Glutamate is released into the synaptic cleft by the presynaptic neuron.
2. Glutamate binds to AMPA receptors, causing them to open and let in Na+.
3. Meanwhile, another type of receptor – the NMDA receptor – remains closed because of a Mg++ block in the pore of the channel.
4. If enough Na+ enters the postsynaptic cell, the postsynaptic cell is depolarized, and the Mg++ block is removed from the NMDA receptor. The NMDA receptor is now open, and it lets in both Na+ and Ca++.
5. Ca++ has two functions in the postsynaptic cell:
    a. It binds to calmodulin and creates calcium-calmodulin-dependent protein kinase II (CaMKII). This kinase phosphorylates AMPA receptors and causes them to increase their conductance to Na+.
    b. It promotes the insertion of new AMPA receptors into the postsynaptic membrane.
6. Next time the presynaptic cell fires and releases glutamate, there are more and better AMPA receptors in the postsynaptic cell awaiting the glutamate. More Na+ is let into the postsynaptic cell, thus strengthening the connection.

Comparing and contrasting LTP and LTD

LTD stands for "long-term depression," and it refers to the modification of synapses that allow them to get weaker. The mechanism is similar to that of LTP, except that less Ca++ enters the postsynaptic cell. A lower concentration of Ca++ will activate phosphatases instead of kinases, because phosphatases are more sensitive to Ca++ than are kinases. Recall that phosphatases remove phosphate groups from proteins. They will dephosphorylate the AMPA receptors and cause their removal from the postsynaptic membrane, thus weakening the synapse.

The table below compares and contrasts the features of LTP and LTD. You should be comfortable with these concepts:

	LTP	LTD
Change in synaptic strength	Positive (stronger)	Negative (weaker)
Frequency of stimulation needed	High frequency (~100 Hz)	Low frequency (~10 Hz)
Concentration of intracellular calcium	High concentration	Low concentration
Types of enzymes activated	Protein kinases	Protein phosphatases

Concluding remarks about learning and memory

- Memory consolidation is the process of transforming a short-term memory to a long-term memory. This process requires protein synthesis.
- CREB is a transcription factor that may play a role in memory. A transcription factor basically binds to DNA and regulates its transcription (DNA to mRNA).

Happy Thanksgiving!