Dendritic branch is preferred integrative unit for protein synthesis-dependent LTP

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Neuroscientists at MIT's Picower Institute of Learning and Memory have uncovered why relatively minor details of an episode are sometimes inexplicably linked to long-term memories. The work, slated to appear in the Jan. 13, 2011 issue of *Neuron*, explains at a molecular level for the first time.

"Our finding explains, at least partially, why seemingly irrelevant information like the color of the shirt of an important person is remembered as vividly as more significant information such as the person's impressive remark when you recall an episode of meeting this person," said co-author Susumu Tonegawa, Picower Professor of Biology and Neuroscience and Director of the RIKEN-MIT Center for Neural Circuit Genetics.

The data also showed that irrelevant information that follows the relevant event rather than precedes it is more likely to be integrated into long-term memory.

Shaping a memory

One theory holds that memory traces or fragments are distributed throughout the brain as biophysical or biochemical changes called engrams. The exact mechanism underlying engrams is not well understood.

MIT neuroscientists Arvind Govindarajan, assistant director of the RIKEN/MIT Center for Neural Circuit Genetics; Picower Institute postdoctoral associate Inbal Israely; and technical associate Shu-Ying Huang; and Susumu Tonegawa looked at single neurons to explore how memories are created and stored in the brain.

Previous research has focused on the role of synapses—the connections through which neurons communicate. An individual synapse is thought to be the minimum unit necessary to establish a memory engram.

Instead of looking at individual synapses, the MIT study explored neurons' branch-like networks of dendrites and the multiple synapses within them.

Boosting the signal

In response to external stimuli, dendritic spines in the cerebral cortex undergo structural remodeling, getting larger in response to repeated activity within the brain. This remodeling is thought to underlie all learning and memory.

Neurons sprout branch-like dendrites that transmit incoming electrochemical stimulation to the trunk-like cell body. Synapses located at various points throughout the dendritic arbor act as signal amplifiers for the dendrites, which play a critical role in integrating these synaptic inputs and determining the extent to which the neuron acts on incoming signals.

The MIT researchers found that a memory of a seemingly irrelevant detail—the kind of detail that would normally be relegated to a short-term memory--may accompany a long-term memory if two synapses on a single dendritic arbor are stimulated within an hour and a half of each other.

"A synapse that received a weak stimulation, the kind that would normally accompany a short-term memory, will express a correlate of a long-term memory if two synapses on a single dendritic branch were involved in a similar time frame," Govindarajan said.

This occurs because the weakly stimulated synapse can steal or hitchhike on a set of proteins synthesized at or near the strongly stimulated synapse. These proteins are necessary for the enlargement of a dendritic spine that allows the establishment of a long-term memory.

"Not all irrelevant information is recalled, because some of it did not stimulate the synapses of the dendritic branch that happens to contain the strongly stimulated synapse," Israely said. This work was supported by RIKEN, Howard Hughes Medical Institute and the National Institutes of Health.

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