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Study Describes Brain Changes During Learning

ScienceDaily (Oct. 20, 2000) — PROVIDENCE, R.I. — A new study by brain scientists at Brown University provides evidence that learning engages a brain process called long-term potentiation (LTP), which in turn strengthens synapses in the cerebral cortex.

The study provides the strongest evidence to date to support the 25-year-old hypothesis, generally accepted by neuroscientists, that learning uses LTP to produce changes in the connections (synapses) between brain cells (neurons) that are necessary to acquire and store new information, said lead author Mengia-Seraina Rioult-Pedotti.

Neuroscientists also theorize that higher forms of learning occur in the cerebral cortex. Evidence from the study supports that theory.

In the study, published in the Oct. 20 issue of Science, Brown University researchers taught rats to reach into a hole in a box to grasp food pellets, a new motor skill for the animals. After five days, the rats were tested.

The researchers found that not only had the animals' behavior changed, through the learning of a new skill, but that their brains had also changed. Associated with that learning, the strength of synaptic connections between neurons in the motor cortex had increased through a process consistent with the use of LTP.

"Importantly, the overall range of synaptic modification – the maximum possible increase or decrease in strength – had not changed," said Rioult-Pedotti, a neuroscience investigator. "Using this synaptic modification range as a reference allowed our group to eliminate a weakness of earlier work," she said.

In previous studies, the researchers showed that synapses were modifiable through the LTP process when those synapses were activated artificially by electrical impulses. "However, it was not known whether LTP was actually used to modify synapses when learning takes place in the living brain," Rioult-Pedotti said.

"The link between LTP, synaptic modification and learning was tentative," said senior author John Donoghue, professor of neuroscience. "This latest study provides strong evidence that learning itself engages LTP in the cerebral cortex as a way to strengthen synaptic connections."

The research also provides a model to study the relationship between learning and synaptic activity. For example, "the model may be used to study whether synaptic connections get stronger or weaker when you continue learning for long periods of time," Donoghue said. "Or, it gives us a model to test whether drugs or other therapeutic agents can be used to enhance LTP or learning."

Learning and memory are thought to occur through LTP. This is a system in which synapses become increasingly sensitive so that a steady level of pre-synaptic stimulation becomes converted into a larger post-synaptic output. LTP involves patterns of synaptic strengthening and weakening that can last for weeks.

The research further validates the assumptions of a theory proposed by other Brown researchers which says synapses are constantly modifying and that the LTP process is closely related to learning, said Rioult-Pedotti.

Rioult-Pedotti and Donoghue are continuing to examine the relationship between learning and LTP. In particular they are studying which cells and genes are involved in the learning process.

The researchers are also looking at the effect of different training programs on synaptic changes. “We’d like to find what kind of training programs initiate or sustain changes in the cortical circuitry,” Donoghue said. “Is there a brain basis for different kinds of learning? How could you learn something optimally?”

Former Brown undergraduate Daniel Friedman was also an author for the study.

Adapted from materials provided by Brown University.