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Regulating the chemistry of learning

A new study sheds light on how synaptic nerve signals are regulated in the developing brain.

Japanese scientists have published a new study on how nerve signals are transmitted in the brains of young mammals. Their research sheds light on how activity in the developing brain is regulated, avoiding conditions such as epilepsy.

The research focused on the hippocampus region in the brains of young rats. The hippocampus is an area associated with memory and learning. Half is located in the right side of the brain, and half in the left side. It is in this area that a memory must be registered before being stored in the brain.

The team, which included two scientists from RIKEN's Brain Science Institute, examined the role of two chemicals in regulating signals within the brain. These chemicals regulate the speed at which signals cross the synapses, the junctions between neurons. One of them, protein kinase A (PKA) acts to stimulate message transmission across the synapses. This process is called 'long-term potentiation' or LTP. Another group of chemicals called cannabinoids, which are produced by the body, act to depress message transmission, a process called 'long-term depression,' or LTD.

The scientists found that the mechanism that regulates activity in the developing brain is quite different from that in the mature brain. The adult brain regulation mechanism takes time to develop, and in the meantime the developing brain is vulnerable to overactivity. Without an effective mechanism to inhibit nerve signals being transmitted across the synapses, it would be possible for epilepsy to occur.

Epilepsy results from the brain's electrical impulses becoming unstable. In a normal brain, there are approximately 80 nerve impulses per second. In an epileptic seizure, these impulses go out of control, with up to 500 per second occurring. It is thought that this condition occurs in adults when the adult brain's synapse inhibition mechanism is not working properly.

In the developing brain, synapse inhibition, or LTD, is controlled by cannabinoid

chemicals. While such cannabis-like chemicals are produced naturally by the brain, they are also produced from the flowers and leaves of the hemp plant, from which cannabis (marijuana) is produced. They have attracted attention in the scientific community as a potential treatment for epilepsy. While the properties of these plant-produced chemicals in treating seizures has been known since ancient times, such treatment, involving the medical use of marijuana, is at present controversial as marijuana is a controlled substance in many countries. The work of the Japanese scientific team helps to shed light on the exact chemical processes involved.

The research also increases understanding of the processes involved in information storage in the brain. The scientists found that long-term depression of synaptic transmission is a complementary process to long-term potentiation. The brain maintains a dynamic balance between the two processes in response to stimuli. LTP is believed to be the underlying cellular mechanism for learning, including the higher-level cognitive abilities of humans. While it has been known for some time that the exact processes involved differ according to the age, region of the brain and species, the Japanese team has improved knowledge of the learning process as the mammalian brain develops.

Original work:

Yasuda, H., Huang, Y., Tsumoto, T.,
Regulation of excitability and plasticity by endocannabinoids and PKA in developing hippocampus, PNAS, published online on Feb. 18, 2008

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