Ritalin Boosts Learning by Increasing Brain Plasticity

Doctors treat millions of children with Ritalin every year to improve their ability to focus on tasks, but scientists now report that Ritalin also directly enhances the speed of learning.

In animal research, the scientists showed for the first time that Ritalin boosts both of these cognitive abilities by increasing the activity of the neurotransmitter dopamine deep inside the brain. Neurotransmitters are the chemical messengers neurons use to communicate with each other. They release the molecule, which then docks onto receptors of other neurons. The research demonstrated that one type of dopamine receptor aids the ability to focus, and another type improves the learning itself.

The scientists also established that Ritalin produces these effects by enhancing brain plasticity -- strengthening communication between neurons where they meet at the synapse. Research in this field has accelerated as scientists have recognized that our brains can continue to form new connections -- remain plastic -- throughout life.

"Since we now know that Ritalin improves behavior through two specific types of neurotransmitter receptors, the finding could help in the development of better targeted drugs, with fewer side effects, to increase focus and learning," said Antonello Bonci, MD, principal investigator at the Ernest Gallo Clinic and Research Center and professor of neurology at UCSF. The Gallo Center is affiliated with the UCSF Department of Neurology.

Bonci is co-senior author of the paper, published online in *Nature Neuroscience* on March 7, 2010.

Bonci and his colleagues showed that Ritalin's therapeutic action takes place in a brain region called the amygdala, an almond-shaped cluster of neurons known to be critical for learning and emotional memory.

"We found that a dopamine receptor, known as the D2 receptor, controls the ability to stay focused on a task -- the well-known benefit of Ritalin," said Patricia Janak, PhD, co-senior author on the paper. "But we also discovered that another dopamine receptor, D1, underlies learning efficiency."

Janak is a principal investigator at the Gallo Center and a UCSF associate professor of neurology. Lead author of the paper is Kay M. Tye, PhD, a postdoctoral scientist at the Gallo Center when the research was carried out.

The research assessed the ability of rats to learn that they could get a sugar water reward when they received a signal -- a flash of light and a sound. The scientists compared the behavior of animals receiving Ritalin with those that did not receive it, and found those receiving Ritalin learned much better.

However, they also found that if they blocked the dopamine D1 receptors with drugs, Ritalin was unable to enhance learning. And if they blocked D2 receptors, Ritalin failed to improve focus. The experiments established the distinct role of each of the dopamine receptors in enabling Ritalin to enhance cognitive performance.

In addition, animals that performed better after Ritalin treatment showed enhanced synaptic plasticity in the amygdala. Enhanced plasticity is essentially increased efficiency of neural transmission. The researchers confirmed this by measuring electrical activity in neurons in the amygdala after Ritalin treatment.

The research confirmed that learning and focus were enhanced when Ritalin was administered to animals in doses comparable to those used therapeutically in children.

"Although Ritalin is so frequently prescribed, it induces many brain changes, making it difficult to identify which of those changes improve learning." said Kay Tye. "By identifying the brain mechanisms underlying Ritalin's behavioral enhancements, we can better understand the action of Ritalin as well as the properties governing brain plasticity."

Other co-authors on the paper and collaborators in the research were Jackson Cone and Lynne Tye, who were undergraduate assistants at the time of the study, and Evelien Hekkelman, a medical student working with Kay Tye at the Gallo Center.

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Journal Reference:

1. Tye et al. **Methylphenidate facilitates learning-induced amygdala plasticity**. *Nature Neuroscience*, 2010; DOI: 10.1038/nn.2506