Impulsivity, rewards and Ritalin: Monkey study shows tighter link

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Even as the rate of diagnosis has reached 11 percent among American children aged 4 to 17, neuroscientists are still trying to understand attention deficit hyperactivity disorder (ADHD). One classic symptom is impulsivity—the tendency to act before thinking.

Scientifically, impulsivity can appear as a choice for a small but immediate reward over a larger one that requires some delay. Choosing between present and future rewards is a fundamental need in schooling, says Luis Populin, associate professor of neuroscience at University of Wisconsin-Madison. "If you say to an impulsive child, 'Do your homework so you will get a good grade at the end of the quarter,' that has less appeal than 'Let's play baseball this afternoon instead of studying chemistry.'"

To study impulsive behavior, Populin and graduate student Abigail Zdrale Rajala selected two rhesus macaque monkeys with opposite behaviors. One was extremely calm, while the other was nervous, fidgety and impulsive. The monkeys were trained to stare at a dot on a screen and, when it went dark, to choose between two pictures placed to the side. Their choice of picture determined whether they got a small but immediate sip of water, or a larger sip, after a delay ranging up to 16 seconds.

As expected, the calm monkey, but not the impulsive one, quickly figured out that waiting would bring the sweeter result.

This willingness to take a smaller reward right away rather than a larger, delayed reward, called "temporal discounting," is a common feature of "combined type" ADHD, which specifically lists impulsivity among its diagnostic criteria, Populin says.

When the monkeys were given a dose of methylphenidate, the active ingredient of the common ADHD drug Ritalin, they chose the delayed reward more frequently. The impulsive monkey actually showed the same preference for delayed rewards as the unmedicated, calm monkey. However, identifiable differences in their performance mean that methylphenidate improved the condition, but did not eliminate it.

"There is no perfect animal model of ADHD," says Rajala, "but many studies are performed on rodents; this one was done in a non-human primate, which is much closer to humans." The Society for Neuroscience adjudged the paper valuable enough to support Rajala's travel to the conference in San Diego.

Methylphenidate changes the elimination of dopamine, a "reward" neurotransmitter that is elevated by drugs like cocaine and amphetamine. The result is that more dopamine remains in the brain, which is the most likely explanation for the altered reward processing in the medicated monkeys.

Some scientists have thought that temporal discounting in ADHD may result from cognitive processing, which relies on the highly evolved frontal cortex in the brain. The new results support an alternative, but less common, hypothesis: that temporal discounting is linked to the reward-processing mechanism, which is governed by more primitive parts of the brain.

By teasing apart one characteristic of ADHD, the study could help refine drug or behavioral treatments of a disability that has grown 16 percent

more common just since 2007, Populin says.

Provided by University of Wisconsin-Madison