Scientists report role for dopamine and serotonin in human perception and decision-making

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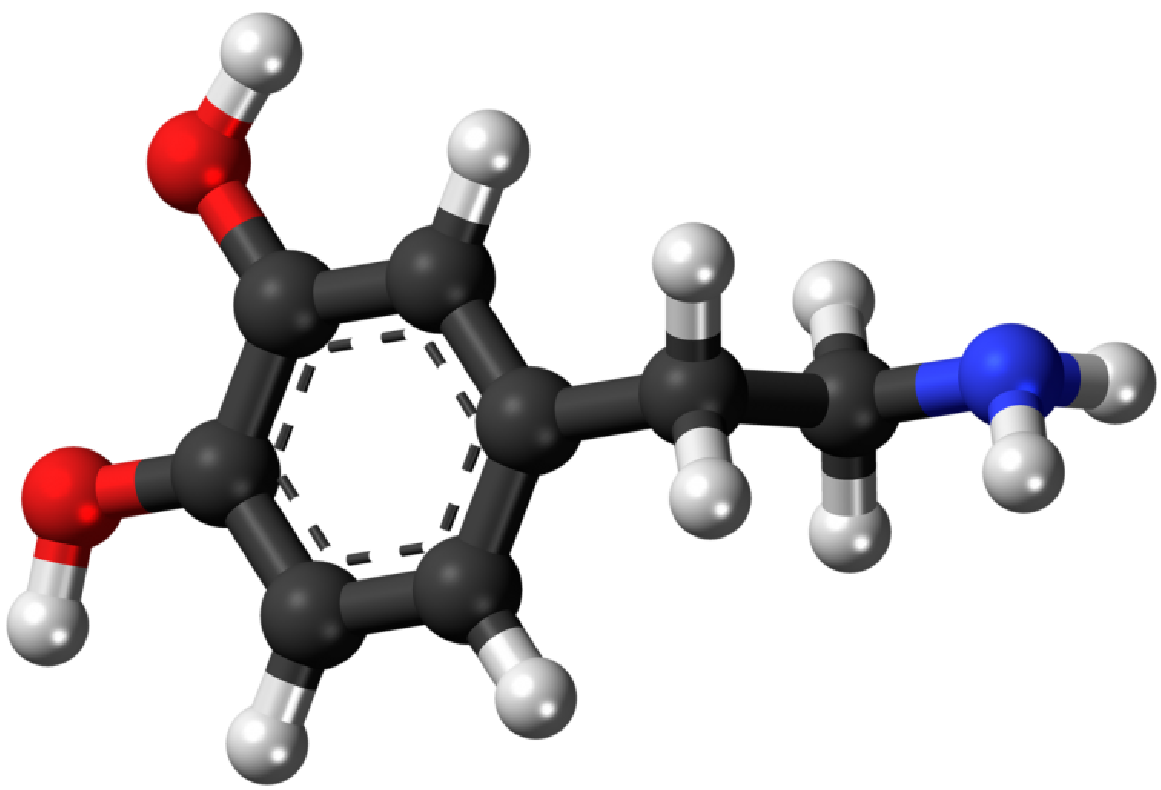

Ball-and-stick model of the dopamine molecule, a neurotransmitter that affects the brain's reward and pleasure centers. Credit: Jynto/Wikipedia

Scientists at Wake Forest School of Medicine have recorded real time changes in dopamine and serotonin levels in the human brain that are involved with perception and decision-making. These same neurochemicals also are critical to movement disorders and psychiatric conditions, including substance abuse and depression.

Their findings are published in the Oct. 12 edition of the journal *Neuron*.

"This study provides us a unique window into the human brain that has been inaccessible until now," said principal investigator Kenneth T. Kishida, Ph.D., assistant professor of physiology and pharmacology and neurosurgery at Wake Forest School of Medicine, part of Wake Forest Baptist Health. "Almost everything we have known mechanistically about these neurochemicals was from work done in preclinical animal models, not from direct evidence from humans."

Having a clearer understanding of how these brain chemicals actually work in people may lead to improved medications or treatments for disorders like Parkinson's disease, substance use disorder or depression, Kishida said.

In this observational study, the neurotransmitters dopamine and serotonin were tracked in five patients using fast scan cyclic voltammetry, an electrochemical technique used to measure dopamine and serotonin, adapted for use in patients. Dopamine and serotonin are chemical messengers used by the nervous system to regulate countless functions and processes in the body.

Study participants—two with Parkinson's and three with essential tremor—were patients at Wake Forest Baptist who were scheduled to receive a deep brain stimulating implant to treat their condition. Working closely with neurosurgeons, Stephen B. Tatter, M.D., and Adrian W. Laxton, M.D., Kishida's team was able to piggyback on the standard surgical mapping process to insert a carbon fiber microelectrode deep into the brain to detect and record serotonin and dopamine released from neurons. The patients with essential tremor were important to the study because, unlike Parkinson's disease which is caused by loss of dopamine-producing neurons, essential tremor is not believed to be caused by changes in dopamine or serotonin function.

While the patients were awake in the operating room, they performed decision-making tasks similar to playing a simple computer game. As they performed the tasks, measurements of dopamine and serotonin were taken in the striatum, the part of the brain that controls cognition, reward and coordinated movements.

Kishida described the game as a series of dots on a computer screen that moved through a "cross-hair" reference point positioned in the center of the screen. Patients had to decide which way the dots were moving. Sometimes the dots would move in the same direction and at other times the dots would move more chaotically making the decision harder.

The dots then disappeared and the patient had to choose which way the dots had moved—clockwise or counter clockwise—relative to a fixed point. This experimental design, created by Kishida's collaborators and co-authors Dan Bang and Stephen M. Fleming, at University College London, allowed the team to tease apart different aspects of how the human brain decides what it has perceived.

This sequence was repeated 200 to 300 times per patient, varying how the dots moved and thus how difficult it was for the patient to decide what they saw. Occasionally, the patients had to indicate how confident they were in their choices.

The test was designed to track the patient's ability to perceive the dots' movement and the patient's confidence in correctly identifying the direction of that movement as a way to determine how dopamine and serotonin actually behaved. The trials were randomized so that predictability from one test trial to the next would be minimized, Kishida said.

The findings showed that the more uncertain the patient was about the direction of the dots, the higher the serotonin levels became. When their certainty increased, serotonin levels decreased.

The study also revealed that, prior to the act of choosing, dopamine rose in anticipation of the choice and serotonin levels fell, and when both reached a certain level, the person made their choice. It's as if dopamine acted like a gas pedal and serotonin acted like a brake and only when both systems were committed was the act of choice (a button press) allowed, Kishida said.

"This study sheds light on the role these neurochemicals play in learning, brain plasticity and how we perceive the environment," Kishida said. "We now have more detailed insight into how our brains build what we perceive, use those perceptions to make decisions, and interpret the consequences of the choices we make. Dopamine and serotonin appear to be critical in all of these processes.

"Importantly, studies like this will help us and other scientists develop a better understanding of how drugs or medications like serotonin reuptake inhibitors affect cognition, decision-making, and impact psychiatric conditions like depression."

Provided by Wake Forest University Baptist Medical Center

https://medicalxpress.com/news/2020-10-scientists-role-dopamine-serotonin-human.html