Examining value-based choices at the level of individual neurons in the human brain

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New research published by investigators at Cedars-Sinai advances scientific understanding of how the brain weighs decisions involving what people like or value, such as choosing which book to read, which

restaurant to pick for lunch—or even, which slot machine to play in a casino. Published today in the journal *Nature Human Behaviour,* this study involved recording the activity of individual human neurons.

The study examined decisions called value-based choices, where there is not necessarily a right or wrong option, according to Ueli Rutishauser, Ph.D., senior author of the study, director of the Center for Neural Science and Medicine, and professor of Neurology, Neurosurgery and Biomedical Sciences at Cedars-Sinai.

"Learning how the brain makes these kinds of choices could help us better understand neurological disorders including addiction and obsessive-compulsive disorder," Rutishauser said, "because all of these conditions can involve a person making the same choice over and over to their detriment."

The 20 study participants, all volunteers, were patients with epilepsy who were hospitalized while doctors monitored their brain activity to determine the focal points of their seizures. This allowed investigators to record the activity of individual neurons within their brains while participants played a computer slot-machine game.

The game, called "two-armed bandit," let participants choose one of two simulated slot machines in each round. Participants pushed a button to select their "bandit," which then either paid out or did not. The bandits had unique markings, so participants could tell whether they had played each one before, and participants played several rounds over a 30-minute period.

Rutishauser explained the factors involved in making value-based choices:

- Familiar options: "If participants had chosen a bandit several

times before, they had a fairly good idea of how often it was a winner."

- Uncertain options: "For bandits they had only played a few times, participants were less certain of their prospect of a win."

- New options: "When a new bandit appeared for the first time, participants had to decide whether to choose a familiar bandit or risk choosing a new one. Sometimes it just feels good to do something new, and that has its own intrinsic value."

Previous studies relied on functional magnetic resonance imaging (MRI) to monitor brain activity, and suggested that a brain region called the ventromedial prefrontal cortex (vmPFC) plays a primary role in weighing these factors. But in this recent study, Cedars-Sinai investigators determined that a completely different area, called the pre-supplementary motor area (pre-SMA), actually takes the lead.

Single-neuron recording allowed investigators to see that while the vmPFC signaled the "novelty" value of new bandits that appeared, it was the pre-SMA that calculated which option had the best chance of yielding the highest reward. And that signal was the basis on which participants made their choices.

"Previous studies weren't giving us a complete picture and couldn't draw the distinction we could here," said Tomas Aquino, Ph.D., a postdoctoral fellow in the Rutishauser Lab and first author of the study. "Since our single-neuron recordings are more sensitive than other, more common methods, we could measure directly how preSMA neurons compute the value of each option and determine participants' choices."

Both the vmPFC and the pre-SMA are part of the brain's frontal lobe, and both have been implicated in planning and decision-making

activities, but in this study, for the first time, investigators were able to tease out their separate roles. This new discovery joins a number of other recent findings indicating that pre-SMA is critically important to human decision-making.

"The unique window into the human brain that is opened by these single-neuron recordings continues to deepen our understanding of the precise mechanisms behind cognitive processes," said Adam Mamelak, MD, director of the Functional Neurosurgery Program at Cedars-Sinai and a co-author of the study. "These continued gains in understanding are the key to finding new treatments for complex neurological disorders and improving the lives of patients."

This research is part of a long-standing collaboration between Cedars-Sinai and co-senior author John O'Doherty, Fletcher Jones Professor of Decision Neuroscience at the California Institute of Technology.

More information: Tomas Aquino, Neurons in human pre-supplementary motor area encode key computations for value-based choice, *Nature Human Behaviour* (2023). DOI: 10.1038/s41562-023-01548-2.
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