Where and when is economic decision-making represented in the brain?

10 February 2021

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Economists have been using game theory to study decision-making since the 1950s. More recently, the interdisciplinary field of neuroeconomics has gained popularity as scientists try to understand how economic decisions are made in the brain. Researchers led by Professor Masayuki Matsumoto and Assistant Professor Hiroshi Yamada at the University of Tsukuba in Japan studied populations of neurons across the monkey brain reward network to find out where and when expected value is calculated.

The team trained monkeys to perform a lottery task for a reward. The monkeys saw two pie charts on a computer screen. The colors in the charts told the monkeys the size of the reward and the probability of getting it. Mathematically, the expected value is the size of the reward multiplied by the chance of getting it. Thus, a highly probable large reward would create a high expected value and a small reward with a low probability would create a low expected value. The monkeys consistently chose the pie chart that depicted the higher expected value, and behavioral models showed that their decisions were indeed based on this integrated value, not simply the probability or the size of the

reward.

The brain has a network of connected regions that all have functions related to processing rewards. The researchers recorded brain activity from four regions that have been implicated in decision-making: the cOFC, mOFC, VS, and DS. They analyzed brain activity when monkeys simply saw one pie chart, but did not have to make any choice. This allowed the researchers to identify brain regions involved in calculating the expected value, not those involved in making choices. They found that all four regions contained neurons that responded to parts of the calculation. Nevertheless, state-space analysis showed that as a population, only the cOFC and VS stably represented the calculated expected value. Additionally, these two regions also stably represented risk-return.

Although both the cOFC and VS integrated reward size and probability, the team noticed that brain cells in these regions did not behave the same way over time. Analysis showed that the expected value signals in the cOFC developed quickly, while those in the VS developed gradually each time the monkey saw one of the pie charts.

Finding that only the cOFC and VS signal expected value differed from previous studies. "Our use of state-space analysis as a means to characterize the dynamics of neuronal populations was the key," explains Matsumoto. "Using this method, we were able to see differences in both stability and as well as the time course of the signal."

Provided by University of Tsukuba

APA citation: Where and when is economic decision-making represented in the brain? (2021, February 10) retrieved 7 June 2022 from https://medicalxpress.com/news/2021-02-economic-decision-making-brain.html