MedicalXpress

Neurons in the frontal lobe may be responsible for rational decision-making

December 9 2007

You study the menu at a restaurant and decide to order the steak rather than the salmon. But when the waiter tells you about the lobster special, you decide lobster trumps steak. Without reconsidering the salmon, you place your order—all because of a trait called "transitivity."

"Transitivity is the hallmark of rational economic choice," says Camillo Padoa-Schioppa, a postdoctoral researcher in HMS Professor of Neurobiology John Assad's lab. According to transitivity, if you prefer A to B and B to C, then you ought to prefer A to C. Or, if you prefer lobster to steak, and steak to salmon, then you will prefer lobster to salmon.

Padoa-Schioppa is lead author on a paper that suggests this trait might be encoded at the level of individual neurons. The study, which appears online Dec. 9 in *Nature Neuroscience*, shows that some neurons in a part of the brain called the orbitofrontal cortex encode economic value in a "menu invariant" way. That is, the neurons respond the same to steak regardless if it's offered against salmon or lobster.

"People make choices by assigning values to different options. If the values are menu invariant preferences will be transitive. The activity of these neurons does not vary with the menu options, suggesting that these neurons could be responsible for transitivity," Padoa-Schioppa explains.

"This study provides a key insight into the biology of our frontal lobes and the neural circuits that underlie decision-making," Assad adds.

“Despite the maxim, we in fact can compare apples to oranges, and we do it all the time. Camillo’s research sheds light on how we make these types of choices.”

Frontal lobe damage has been linked to “choice deficits” such as eating disorders, compulsive gambling and abnormal social behavior. For example, in the first documented case of brain injury impacting behavior, the infamous railroad construction foreman Phineas Gage became unsociable after a tamping iron passed through his skull in 1848, damaging his frontal lobes. This area of the brain has also been implicated in drug abuse.

Labs are just beginning to probe normal decision-making at the level of individual neurons, venturing into a new field called neuroeconomics. Such research might eventually help to explain choice deficits associated with frontal lobe functions.

The new study builds on an April 2006 Nature paper in which Padoa-Schioppa and Assad identified neurons that encode the value macaque monkeys assign to juice they choose independent of its type, providing a common currency of comparison for the brain.

In that study, the scientists found that although monkeys generally prefer grape juice to apple juice, sometimes they choose the latter, if it is offered in large amounts. When presented with 3 units of apple juice and 1 unit of grape juice, for example, a monkey might take the grape juice only 50 percent of the time. This indicates that the value of the grape juice is 3 times that of the apple juice. A particular group of neurons in the orbitofrontal cortex fire at roughly the same rate, regardless of the monkey’s decision because the animal values both choices equally. These neurons also fire at the same rate if the monkey chooses 6 units of apple juice or 2 units of grape juice. Thus, these neurons encode the value the monkey receives in each trial.

Now, by adding a third juice to the mix, the team has tested whether these neurons reflect transitivity. The three juices were offered to a monkey in pairs dozens of times over the course of a session, the quantity of each juice varying from trial to trial.

In general, monkeys preferred 1 unit of juice A to 1 unit of juice B, 1B to 1C, and 1A to 1C. During each session, Padoa-Schioppa recorded the activity of a handful of neurons in the orbitofrontal cortex, and he discovered their firing rate did not depend on whether B was offered against A or against C, indicating that these neurons respond in a menu invariant way.

“The stability of these neurons could help to explain why we make decisions that are consistent over the short term,” Padoa-Schioppa says. “In our study, the neural circuit was not influenced by the short-term behavioral context.”

Padoa-Schioppa is now examining the possibility that value-encoding neurons may adapt to different value scales over longer periods of time.

Source: Harvard Medical School