Locating a 'Free Choice' Brain Circuit

April 17 2008

Your brain gets a better workout when you change your routine, say scientists at the California Institute of Technology who have pinpointed one particular circuit that activates your ability to execute a decision. This finding may help drive research in neural prosthetics and in how unhealthy decisions are made.

"How you decide to do things is fascinating, and not well understood," says Richard Andersen, Caltech's Boswell Professor of Neuroscience and senior researcher in the study. "We're looking at how different areas interact during the process--how you make a decision to plan a movement."

Andersen and his two collaborators focused on the cortex, the part of the brain where language, memories, and awareness of the outside world develop. They found that when choices are open, the brain's frontal and parietal cortices relay clear signals back and forth. In contrast, when a decision and the path to execute it are dictated, the correlation between these regions is significantly weaker.

"These findings show that different parts of the brain are working together. The premotor region--in the frontal cortex--first forms the plan; then once the signal travels to the parietal cortex, this second region sends back a 'handshake' as if to say, 'okay, I got it,'" explains Andersen.

To examine the circuit involved in decision making, two adult male monkeys were first dictated a specific sequence in which to touch three different shapes on a touch-sensitive screen in order to win a sip of liquid. After that, they were presented with a screen showing all circles, and only a randomly picked circle yielded the reward. Each monkey touched the circles in varying orders from trial to trial, suggesting he was making his own decisions. "When only circles are displayed, he knows the choices are free and that he'll get rewarded eventually," Andersen notes.

During these trials, tiny wires were planted close to neurons in both cortical areas. There are no pain endings in the brain, so the monkeys did not feel any discomfort, but the wires allowed the neural signals, the pulse-like waves of voltage called action potentials, to be recorded. A frequency band of the action potentials from a cell in one cortical area often matched a frequency band of the local field--a local voltage oscillation related to the synaptic potentials--in the other area. When the monkey was making his own choices, this correlation, or coherence, was significantly stronger than when he was following instructions.

"It may be more difficult to make your own choices, and this may be related to the increased coherence," Andersen remarks. "The cells that show coherence were also the first to show the direction the monkey chose to go," he adds, noting also that the short duration of coherence likely reflects that the decision is made very early on.

While the scenario examined here focused on situations that are immediately rewarded, Andersen says, "Even the long-range decisions that are made in other areas require this circuit to put them into play."

The implications for this research are manifold. "How does someone form preferences and plan movements to control a prosthetic arm, for example?" Andersen remarks. He also notes that mental illness, aging, or even fatigue, not to mention the extreme case of addiction, can drive unhealthy choices. Once the regions of the brain responsible for free choice are deciphered, poor decision making may also be better understood.

Other authors on the study, appearing April 16 in the early online edition of the journal *Nature*, are Bijan Pesaran, a former Caltech postdoc with Andersen and now an assistant professor at New York University, and Matthew Nelson, a Caltech graduate student in computation and neural systems.

Source: Caltech