Medical Xpress

Brain implant reveals the neural patterns of attention

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A paralyzed patient implanted with a brain-computer interface device has allowed scientists to determine the relationship between brain waves and attention.

Characteristic activity patterns known as beta and delta oscillations have been observed in various regions of the brain since the early 20th century, and have been theoretically associated with attention. The unique opportunity to record directly from a human subject's motor cortex allowed University of Chicago researchers to investigate this relationship more thoroughly than ever before.

"This gave us a really unique opportunity to record, at the micro scale, signals from the human motor cortex," said Hatsopoulos, professor in the Department of Organismal Biology and Anatomy and Chair of the Committee on Computational Neuroscience.

The experiments, published this week in the journal *Neuron*, reveal the intricate dynamics of the attentive brain. Beta oscillations can be read as a reflection of how much attention a subject is paying to the task at hand, while slower delta oscillations act as an internal metronome, allowing the brain to anticipate moments when attention is most needed.

"Our study shows that when a person can count at a rhythm provided by an external stimulus, your brain can act as a metronome to take advantage of this timing and become more efficient," said Maryam Saleh, graduate student in the Committee on Computational

Neuroscience and lead author of the study.

The experimental subject was implanted with a BrainGate neuroprosthetic implant in 2006, a device that allows quadriplegic individuals to control a computer cursor using brain activity. As part of a clinical trial, a small chip containing nearly 100 microelectrodes was implanted in the subject's primary motor cortex, where electrical signals could be translated by computer into cursor motion directed by the patient's thoughts.

In the experiments described in *Neuron*, Saleh and colleagues from the laboratory of Nicholas Hatsopoulos recorded electrical activity, called local field potentials, collected by the implanted chip as the subject performed a simple computer task. The subject was shown a series of five instructions of where to move a cursor, but told to only follow the second or fourth instruction and disregard the rest.

The recordings found a characteristic pattern of activity as the subject paid close attention to the task. High-frequency beta oscillations increased in strength as the subject waited for the relevant instruction, with peaks of activity occurring just before each instructional cue. After receiving the relevant instruction and before the subject moved the cursor, the beta oscillation intensity fell dramatically to lower levels through the remaining, irrelevant instructions.

"Previously, no one has been able to dissociate if beta oscillations are related to attention or to just holding, waiting to initiate movement," Saleh said. "Our results show that these oscillations are tied to the anticipation of oncoming information that is used to make a movement."

The slower delta oscillation also showed a regular pattern as the subject performed the task, adjusting its frequency to mirror the timing of each instructional cue. The authors suggest that this "internal metronome" function may help fine-tune beta oscillations, so that maximum attention is paid at the appropriate time.

"There are lots of stimuli in the world that have rhythm," said Jacob Reimer, post-doctoral researcher at Baylor College of Medicine and another author of the study. "If you're waiting for a signal that is informative, you could pay attention constantly for a long period of time. But if that thing you're waiting for has some rhythmicity to it, maybe a more efficient method is to only pay attention 'on the beat.'"

For example, when someone is playing tennis or basketball, the brain may utilize the rhythm of a volley or a dribble to better attune its attention and motor response. To make this fine-tuning possible, electrical oscillations at different frequencies in cortex may play off each other like the instruments of a jazz band.

"The slow rhythm is kind of like the rhythm section, and you anticipate notes at particular moments in time based on that slower rhythm." Hatsopoulos explained.

This new understanding of the relationship between brain activity and attention may have relevance in the field of neuropsychology, where EEG recordings are able to pick up beta and delta oscillations with reduced spatial resolution. A diagnostic and therapeutic tool could be developed that uses such recordings to assess a person's attention from moment to moment, Hatsopoulos speculated, with the signal fed back to the person to improve their attention.

The rhythmic patterns of oscillations may also be useful in developing better brain-machine interface technology for quadriplegic individuals to operate prosthetics, Saleh said.

"The brain-computer interface is meant to help a person move a cursor with his thoughts about movement," Saleh said. "But when a person is 'plugged into' a brain-computer interface, he doesn't always want to use it; occasionally, he might just want to tune out and do nothing. Using features from these oscillations, the computer can determine when a patient is ready to move."

The ability to understand the role these oscillations play in the motor cortex of humans was "unbelievably valuable," said Charles Schroeder, a professor of psychiatry at Columbia University College of Physicians and Surgeons who has previously studied low-frequency oscillations in cortex.

"All these things converge on this idea that low-frequency oscillations reflect the brain's plans; they are really critical," Schroeder said. "Understanding the oscillatory dynamics of cortex helps you think about how you can develop therapies that help the cortex learn or re-learn after damage."

More information: The paper, "Fast and Slow Oscillations in Human Primary Motor Cortex Predict Oncoming Behaviorally Relevant Cues," will appear in the February 25, 2010 issue of Neuron.

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