Sensory detection and discrimination: Study reveals neural basis of rapid brain adaptation

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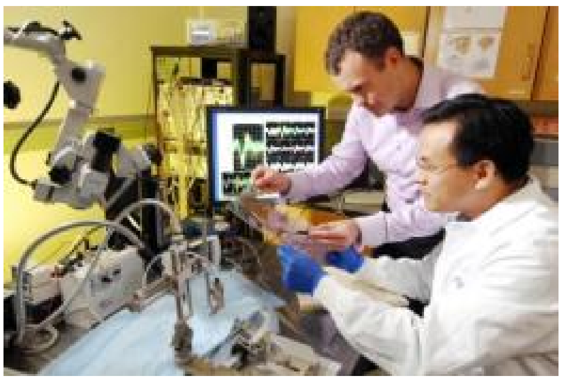

Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University associate professor Garrett Stanley (standing) and research scientist Qi Wang uncovered the biological basis of the brain's ability for rapid adaptation: neurons located at the beginning of the brain's sensory information pathway that change their level of simultaneous firing. Credit: Georgia Tech/Gary Meek

(PhysOrg.com) -- You detect an object flying at your head. What do you do? You probably first move out of the way — and then you try to determine what the object is. Your brain is able to quickly switch from detecting an object moving in your direction to determining what the object is through a phenomenon called adaptation.

A new study in the Nov. 21 advance online edition of the journal Nature Neuroscience details the biological basis of this ability for rapid adaptation: neurons located at the beginning of the brain's sensory information pathway that change their level of simultaneous firing. This modification in neuron firing alters the nature of the information being relayed, which enhances the brain's ability to discriminate between different sensations — at the expense of degrading its ability to detect the sensations themselves.

"Previous studies have focused on how brain adaptation influences how much information from the outside world is being transmitted by the thalamus to the cortex, but we show that it is also important to focus on what information is being transmitted," said Garrett Stanley, an associate professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University.

In addition to Stanley, Coulter Department research scientist Qi Wang and Harvard Medical School Neurobiology Department research fellow Roxanna Webber contributed to this work, which is supported by the National Institutes of Health.

For the experiments, Stanley and Wang moved a rat's whisker to generate a sensory input. Moving whiskers at different speeds or at different angles produced sensory inputs that could be discriminated. This sensory experience is analogous to an individual moving a fingertip across a surface and perceiving the surface as smooth or rough. While the whiskers were being moved, the researchers recorded neural signals simultaneously from different parts of the animal's brain to determine what information was being transmitted.

"Neuroscientists know a lot about different parts of the brain, but we don't know a lot about how they talk to each other. Recording how neurons are simultaneously communicating with each other in different parts of the brain and studying how the communication changes in different situations is a big step in this field," said Stanley.

The results from the experiments showed that adaptation shifted neural activity from a state in which the animal was good at detecting the presence of a sensory input to a state in which the animal was better at discriminating between sensory inputs. In addition, adaptation enhanced the ability to discriminate between deflections of the whiskers in different angular directions, pointing to a general phenomenon.

"Adaptation differentially influences the thalamus and cortex in a manner that fundamentally changes the nature of information conveyed about whisker motion," explained Stanley. "Our results provide a direct link between the long-observed phenomenon of enhanced sensory performance with adaptation and the underlying neurophysiological representation in the primary sensory cortex."

The thalamus serves as a relay station between the outside world and the cortex. Areas of the cortex receive and process information related to vision, audition and touch from the thalamus.

The study also revealed that information the cortex receives from the thalamus is transformed as it travels through the pathway due to a change in the level of simultaneous firing of neurons in the thalamus. The researchers found that the effect of adaptation on the synchrony of neurons in the thalamus was the key element in the shift between sensory input detection and discrimination.

"There is a switching of the circuit to a different function. The same neurons do two different things and switch quickly, in a matter of seconds or milliseconds, through a change in the synchronization across neurons," explained Stanley. "If we think of the neurons firing like members of an audience clapping hands, then the sound of the clapping becomes louder when they all clap together."

In the future, the techniques used in this study may be valuable for probing the effects of brain injury on this pathway and others, as a variety of different diseases and disorders act to change the degree of synchronization of neurons in the brain, resulting in harmful effects.

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