Research shows brain more flexible, trainable than previously thought

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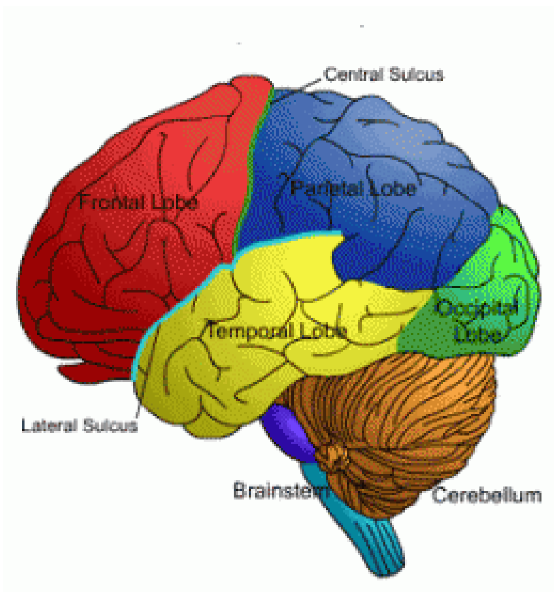

Brain diagram. Credit: dwp.gov.uk

Opening the door to the development of thought-controlled prosthetic devices to help people with spinal cord injuries, amputations and other impairments, neuroscientists at the University of California, Berkeley, and the Champalimaud Center for the Unknown in Portugal have demonstrated that the brain is more flexible and trainable than previously thought.

Their new study, to be published Sunday, March 4, in the advanced online publication of the journal *Nature*, shows that through a process called plasticity, parts of the brain can be trained to do something it normally does not do. The same brain circuits employed in the learning of motor skills, such as riding a bike or driving a car, can be used to master purely mental tasks, even arbitrary ones.

Over the past decade, tapping into brain waves to control disembodied objects has moved out of the realm of parlor tricks and parapsychology and into the emerging field of neuroprosthetics. This new study advances work by researchers who have been studying the brain circuits used in natural movement in order to mimic them for the development of prosthetic devices.

"What we hope is that our new insights into the brain's wiring will lead to a wider range of better prostheses that feel as close to natural as possible," said Jose Carmena, UC Berkeley associate professor of electrical engineering, cognitive science and neuroscience. "They suggest that learning to control a BMI (brain-machine interface), which is inherently unnatural, may feel completely normal to a person, because this learning is using the brain's existing built-in circuits for natural motor control."

Carmena and co-lead author Aaron Koralek, a UC Berkeley graduate student in Carmena's lab, collaborated on this study with Rui Costa, co-principal investigator of the study and principal investigator at the Champalimaud Neuroscience Program, and co-lead author Xin Jin, a post-doctoral fellow in Costa's lab.

Previous studies have failed to rule out the role of physical movement when learning to use a prosthetic device.

"This is key for people who can't move," said Carmena, who is also co-director of the UC Berkeley-UCSF Center for Neural Engineering and

Prostheses. "Most brain-machine interface studies have been done in healthy, able-bodied animals. What our study shows is that neuroprosthetic control is possible, even if physical movement is not involved."

To clarify these issues, the scientists set up a clever experiment in which rats could only complete an abstract task if overt physical movement was not involved. The researchers decoupled the role of the targeted motor neurons needed for whisker twitching with the action necessary to get a food reward.

The rats were fitted with a brain-machine interface that converted brain waves into auditory tones. To get the food reward – either sugar-water or pellets – the rats had to modulate their thought patterns within a specific brain circuit in order to raise or lower the pitch of the signal.

Auditory feedback was given to the rats so that they learned to associate specific thought patterns with a specific pitch. Over a period of just two weeks, the rats quickly learned that to get food pellets, they would have to create a high-pitched tone, and to get sugar water, they needed to create a low-pitched tone.

If the group of neurons in the task were used for their typical function – whisker twitching – there would be no pitch change to the auditory tone, and no food reward.

"This is something that is not natural for the rats," said Costa. "This tells us that it's possible to craft a prosthesis in ways that do not have to mimic the anatomy of the natural motor system in order to work."

The study was also set up in a way that demonstrated intentional, as opposed to habitual, behavior. The rats were able to vary the amount of pellets or sugar water received based upon their own level of hunger or thirst.

"The rats were aware; they knew that controlling the pitch of the tone was what gave them the reward, so they controlled how much sugar water or how many pellets to take, when to do it, and how to do it in absence of any physical movement," said Costa.

Researchers hope these findings will lead to a new generation of prosthetic devices that feel natural.

"We don't want people to have to think too hard to move a robotic arm with their brain," said Carmena.

Provided by University of California - Berkeley