Monkeys feel, move virtual objects using only their brains (w/ video)

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A rhesus macaque monkey is seen in Hong Kong in April 2011. Monkeys implanted with brain electrodes were able to see and move a virtual object and sense the texture of what they saw, a step forward in the quest to help the severely paralysed touch the outside world once more.

(Medical Xpress) -- In a first ever demonstration of a two-way interaction between a primate brain and a virtual body, two monkeys trained at the Duke University Center for Neuroengineering learned to employ brain activity alone to move an avatar hand and identify the texture of virtual objects.

"Someday in the near future, quadriplegic patients will take advantage of this technology not only to move their arms and hands and to walk again, but also to sense the texture of objects placed in their hands, or experience the nuances of the terrain on which they stroll with the help of a wearable robotic exoskeleton," said Miguel Nicolelis, M.D., Ph.D., professor of neurobiology at Duke University Medical Center and co-director of the Duke Center for Neuroengineering, who was senior author of the study.

Without moving any part of their real bodies, the monkeys used their electrical brain activity to direct the virtual hands of an avatar to the surface of virtual objects and, upon contact, were able to differentiate their textures.

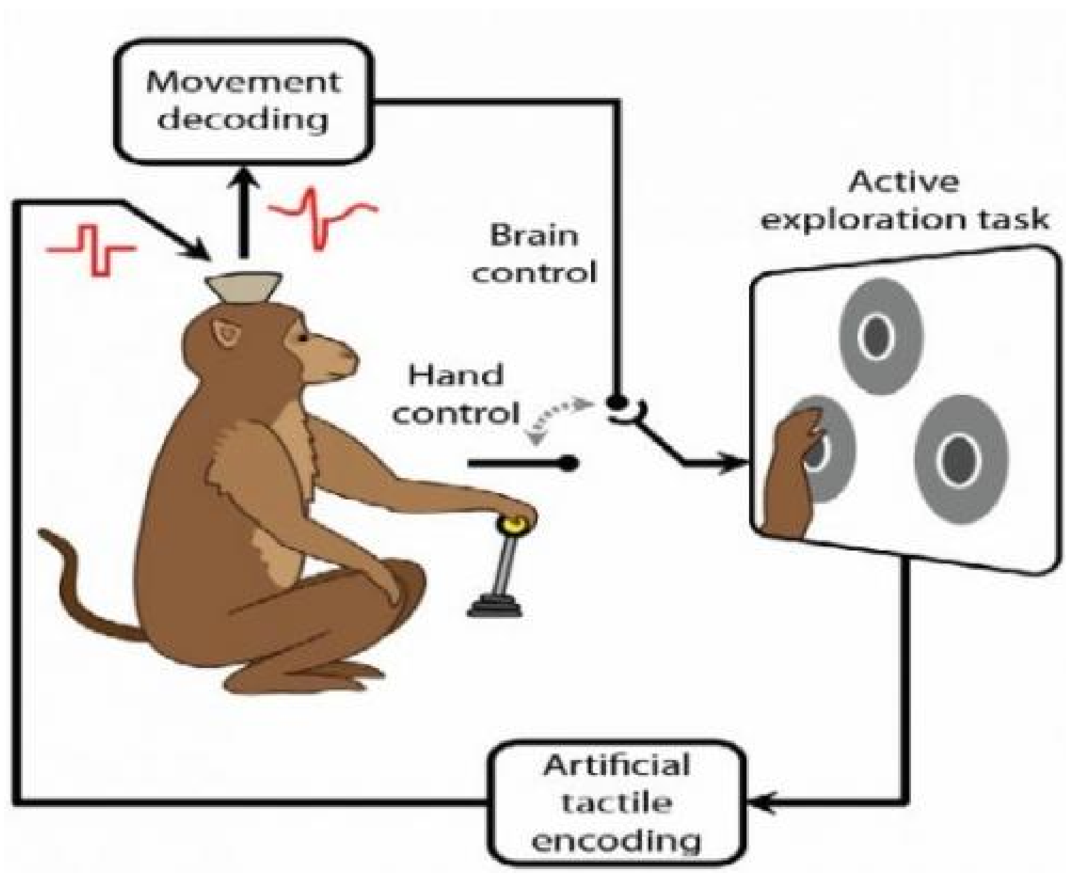
Although the virtual objects employed in this study were visually identical, they were designed to have different artificial textures that could only be detected if the animals explored them with virtual hands controlled directly by their brain's electrical activity.

The texture of the virtual objects was expressed as a pattern of minute electrical signals transmitted to the monkeys' brains. Three different electrical patterns corresponded to each of three different object textures.

Because no part of the animal's real body was involved in the operation of this brain-machine-brain interface (BMBI), these experiments suggest that in the future patients severely paralyzed due to a spinal cord lesion may take advantage of this technology, not only to regain mobility, but also to have their sense of touch restored, said Nicolelis, who was senior author of the study published in the journal *Nature* on Oct. 5.

"This is the first demonstration of a brain-machine-brain interface that establishes a direct, bidirectional link between a brain and a virtual body," Nicolelis said. "In this BMBI, the virtual body is controlled directly by the animal's brain activity, while its virtual hand generates tactile feedback information that is signaled via direct electrical microstimulation of another region of the animal's cortex."

"We hope that in the next few years this technology could help to restore a more autonomous life to many patients who are currently locked in without being able to move or experience any tactile sensation of the surrounding world," Nicolelis said.



"This is also the first time we've observed a brain controlling a virtual arm that explores objects while the brain simultaneously receives electrical feedback signals that describe the fine texture of objects 'touched' by the monkey's newly acquired virtual hand," Nicolelis said. "Such an interaction between the brain and a virtual avatar was totally independent of the animal's real body, because the animals did not move their real arms and hands, nor did they use their real skin to touch the objects and identify their texture. It's almost like creating a new sensory channel through which the brain can resume processing information that cannot reach it anymore through the real body and peripheral nerves."

The combined electrical activity of populations of 50-200 neurons in the monkey's motor cortex controlled the steering of the avatar arm, while thousands of neurons in the primary tactile cortex were simultaneously receiving continuous electrical feedback from the virtual hand's palm that let the monkey discriminate between objects, based on their texture alone.

"The remarkable success with non-human primates is what makes us believe that humans could accomplish the same task much more easily in the near future," Nicolelis said.

It took one monkey only four attempts and another nine attempts before they learned how to select the correct object during each trial. Several tests demonstrated that the monkeys were actually sensing the object and not selecting them randomly.

The findings provide further evidence that it may be possible to create a robotic exoskeleton that severely paralyzed patients could wear in order to explore and receive feedback from the outside world, Nicolelis said. Such an exoskeleton would be directly controlled by the patient's voluntary brain activity in order to allow the patient to move autonomously. Simultaneously, sensors distributed across the exoskeleton would generate the type of tactile feedback needed for the patient's brain to identify the texture, shape and temperature of objects, as well as many features of the surface upon which they walk.

This overall therapeutic approach is the one chosen by the Walk Again

Project, an international, non-profit consortium, established by a team of Brazilian, American, Swiss, and German scientists, which aims at restoring full body mobility to quadriplegic patients through a brain-machine-brain interface implemented in conjunction with a full-body robotic exoskeleton.

The international scientific team recently proposed to carry out its first public demonstration of such an autonomous exoskeleton during the opening game of the 2014 FIFA Soccer World Cup that will be held in Brazil.

More information: O'Doherty, J. E. et al. *Nature* advance online publication, dx.doi.org/10.1038/nature10489 (2011).

Provided by Duke University Medical Center