MEDIA ALERT

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Neuroscientists demonstrate operation of the first network of brains (Brainets) in both primates and rodents

Neuroscientists at Duke University have introduced a new paradigm for brain-machine interfaces that investigates how the brains of two or more animals (either monkeys or rats) can be networked to work together as part of a single computational system to perform motor tasks (in the case of monkeys) or simple computations (multiple rat brains). These functional networks of animal brains have been named Brainets by the authors of the studies. In the two Brainet examples reported in the July 9th 2015 issue of Scientific Reports, groups of animals were able to literally merge their collective brain activity together to either control the movements of a virtual avatar arm in three dimensions to reach a target (monkey Brainet), or to perform a variety of computational operations (rat Brainet), including pattern recognition, storage and retrieval of sensory information and even weather forecasting. These latter examples suggest that animal Brainets could serve as the core of organic computers that employ a hybrid digital-analog computational architecture.

Brain-machine interfaces (BMIs) are computational systems that allow subjects to use their brain signals to directly control the movements of artificial devices, such as robotic arms, exoskeletons or virtual avatars. The Duke researchers, working at the Center for Neuroengineering, have previously built BMIs to capture and transmit the brain signals of individual rats, monkeys, and even human subjects to artificial devices. In the first of the studies published this week, the scientists linked two or three rhesus macaque monkeys in a network that they named Brainet. They used this Brainet to investigate the physiological properties and adaptability of brain circuits when the animals worked together just by combining their collective brain activity.

The rhesus monkeys were outfitted with arrays implanted in their motor and somatosensory cortices to capture and transmit their brain activity. For one experiment highlighted in the article, two monkeys were placed in separate rooms where they observed identical images of an avatar on a display monitor in front of them.

One animal controlled the avatar's horizontal movement along an x-axis, and the other controlled vertical movements along a y-axis. The monkeys worked together to move the avatar on the screen to touch a moving target.

In another experiment, researchers recorded the electrical activity of more than 700 neurons from the brains of three monkeys as they moved a virtual arm toward a target. In this experiment, each monkey mentally controlled two out of three dimensions (i.e. X-Y, Y-Z, and X-Z, see included video) of a virtual arm movement in 3D space. The monkeys could only be successful when at least two of them synchronized their brains to produce continuous 3-D signals that moved the virtual arm towards a target.

As the animals gained more experience and training in the motor task, researchers found that they adapted to the challenge.

"Participating in the Brainet, all three monkeys were able to synchronize their brain activity to produce a unified output capable of moving the virtual arm in 3-D," said Miguel Nicolelis, M.D., Ph. D., co-director of the Center for Neuroengineering at the Duke University School of Medicine and principal investigator of the study.

"This is the first demonstration of a shared brain-machine interface, a paradigm that has been translated successfully over the past decades from studies in animals all the way to clinical applications. We foresee that shared-BMIs will follow the same track and soon be translated to clinical practice." Nicolelis said.

Overall, the monkeys were more successful in reaching the target when they worked in concert, as opposed to performing the task individually, suggesting that the animals were able to take advantage of the collective work of the Brainet to achieve their common goal. To achieve this performance, all monkeys had to synchronize their collective brain activity to produce a "supra-brain" which was in charge of generating the 3D movements of the virtual arm.

Nicolelis and colleagues of the Walk Again Project, based in the project's laboratory in Brazil, are currently working to implement a non-invasive human Brainet to be employed in their neuro-rehabilitation training paradigm with severely paralyzed patients.

The second Brainet study, involving groups of three to four rats whose brains have been interconnected via pairwise brain-to-brain interfaces (BtBIs) further demonstrates how groups of animals' brains can be combined to perform a variety of simple computational tasks. This study extends the original concept of BtBI to multiple subjects and shows how groups of animal brains can synchronize very quickly in order to solve a given computational task. Under some conditions, the authors observed that the rat Brainet could perform at the same level or even better than individual rats on a given task. These results support the original claim of the same group that Brainets may serve as test beds for the development of organic computers created by the interfacing of multiple animals brains with computers. This arrangement would employ a hybrid digital-analog computational engine as the basis of its operation, in a clear departure from the classical digital-only mode of operation of modern computers.