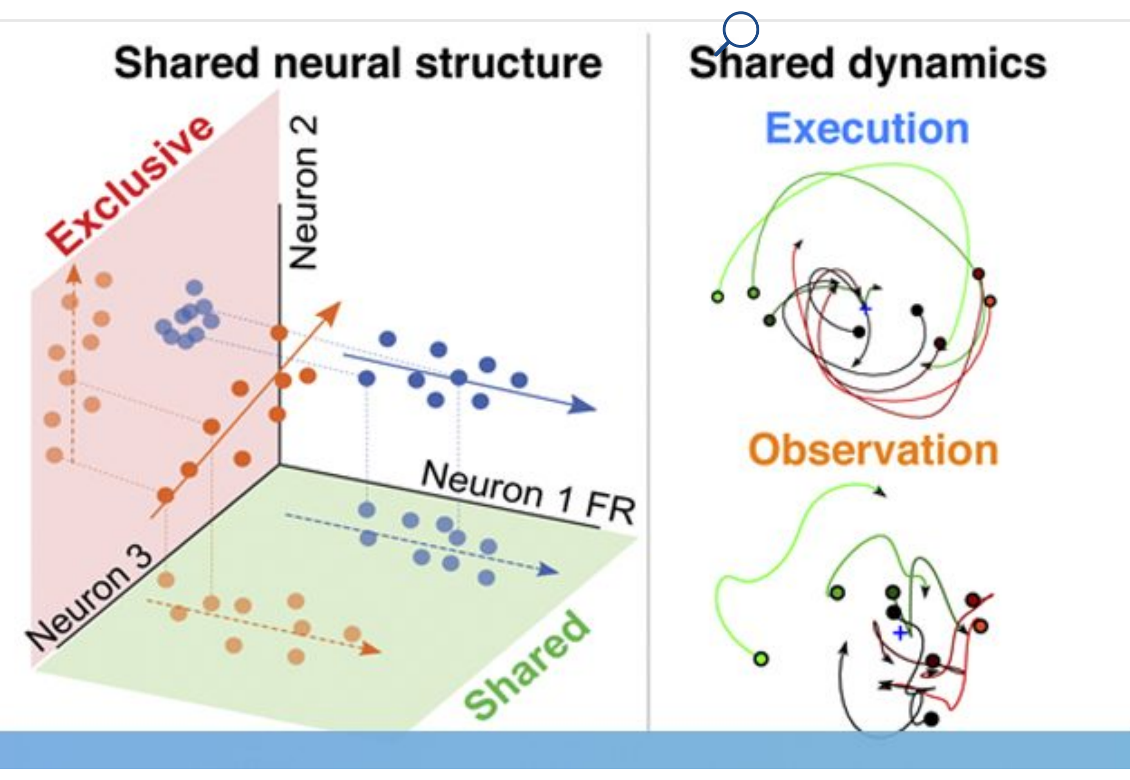

Learning vs. Doing: How the Brain Interprets Observation and Action

UCLA study shows understanding of shared neuron circuits in the brain may help improve movement for paraplegics in the future

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By UCLA Samueli Newsroom

When you watch a professional basketball player shoot a free throw, then go out to your local court and try to replicate the exact same motion, your brain treats both situations — observation and action —with a great deal of similarities, down to sharing many of the same neurons.

But at the cellular level, the picture is more complex than just shared neurons. In a new study published in Cell Reports, a UCLA-led team has changed the way scientists think about how observation and action are coded in the brain. The study shows that learning a movement and then repeating it involve more than just shared neurons. Instead, it is more akin to a shared circuit of neurons.

The research, led by Jonathan Kao, an assistant professor of electrical and computer engineering at the UCLA Samueli School of Engineering, could offer new insight into how the brain works, how it learns, and even how to develop improved brain-machine interfaces that connect artificial limbs.

Other researchers had previously identified "congruent" neurons, which fire similarly whether you observe someone perform an action, or perform the action yourself. The prevailing opinion was that this group of congruent neurons coded what was similar in a movement, such as the motion of a good free throw. "Incongruent" neurons, however, coded the differences between observing and acting, such as activating your muscles to shoot the free throw. "But our study shows this is not the case and there's more nuance involved," Kao said. "Instead of thinking about how each neuron codes for observation versus action, we should think of the computations of the larger circuit, which comprises many neurons acting in coordination."

That coordination among multiple neurons is analogous to an orchestra, with each neuron representing an individual instrument.

"The brain's activity during observation and action are like two songs that sound alike," Kao said. "We showed a part of the brain's circuit was activated similarly in both observation and action, much like a shared musical theme or motif between the two songs that make them sound similar.

"We also showed that in both scenarios, it wasn't just the same instruments, the congruent neurons, playing that shared theme but that it was also played by different instruments, the incongruent neurons," he added. "We believe this shared circuit computation in the brain shapes learning between observation and action."

Experiments for the study were conducted with monkeys first observing a computer cursor moving, and then moving their arms to control the cursor employing virtual reality. The researchers recorded signals from the brain's premotor and motor cortex regions, which are typically associated with planning and executing movements.

Kao says this research has implications for brain-machine interfaces, which aim to restore communication and movement to those with paralysis. In brain-machine interfaces, neural activity is decoded into the movements of machines and computers, such as a robotic arm or computer cursor. Understanding the circuit patterns in observation and action may lead to more accurate decoding of neural activity, enabling more precise and proficient control of machines.

Co-authors of the study include Xiyuan Jiang, who is the first author on the paper; and Hemant Saggar — recent UCLA Samueli master's and doctoral degree recipients respectively; as well as Dr. Stephen I. Ryu, a neurosurgeon at Stanford Hospitals and Clinics; and Krishna Shenoy, Stanford University's Hong She and Vivian W. M. Lim Professor of Engineering.

Kao leads the Neural Computation and Engineering Laboratory at UCLA. Funding for his research is in part provided by the National Science Foundation. Additional support for the other researchers came from the Christopher and Dana Reeve Paralysis Foundation, National Institutes of Health, Defense Advanced Research Projects Agency, Simons Foundation, Office of Naval Research, and Howard Hughes Medical Institute.