Does the brain control muscles or movements?

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One of the major scientific questions about the brain is how it can translate the simple intent to perform an action—say, reach for a glass—into the dynamic, coordinated symphony of muscle movements required for that action. The neural instructions for such actions originate in the brain's primary motor cortex, and the puzzle has been whether the neurons in this region encode the details of individual muscle activities or the high-level commands that govern kinetics—the direction and velocity of desired movements.

Now, Robert Ajemian and his colleagues, analyzing muscle function in monkeys, have created a mathematical model that captures the control characteristics of the motor cortex. It enabled the researchers to better sort out the "muscles-or-movement" question.

The researchers described their model in an article in the May 8, 2008, issue of the journal *Neuron*, published by Cell Press.

Researchers have been thwarted in their efforts to measure and model the neural control of complex motions because muscle forces and positions constantly change during such motions. Also, the position sensors, called proprioceptors, in joints and muscles feed back constantly changing signals to the neurons of the motor cortex.

Ajemian and colleagues overcame these complexities by simplifying the experimental design. Rather than asking monkeys to carry out complex movements, they trained the animals to push on a joystick in different, specified ways to move a cursor on a screen to a desired target. This use of isometric force greatly simplified the measurements the researchers needed to make to define muscle and joint action.

As the monkeys carried out the isometric tasks, the researchers analyzed the patterns of muscle activations that corresponded with the isometric forces in different directions and at different postures. They then developed a model that enabled them to test hypotheses about the relationship between neuronal activity that they measured in the animals' motor cortex and the resulting actions.

They said that their "joint torque model can be tested at the resolution of single cells, a level of resolution that, to our knowledge, has not been attained previously."

They concluded that their model "suggests that neurons in the motor cortex do encode the kinetics of motor behavior."

"This model represents a significant advance, because it is strikingly successful in accounting for the way that the responses of individual [primary motor cortex] neurons vary with posture and force direction," commented Bijan Pesaran and Anthony Movshon in a preview of the article in the same issue of Neuron.

"The results of Ajemian et al's analysis provide strong evidence that it is useful to think of the output of [primary motor cortex] neurons in terms of their influence on muscles. Their model, in effect, defines a 'projection field' for each [primary motor cortex] neuron that maps its output into a particular pattern of muscle actions."

Pesaran and Movshon commented that "perhaps we should set aside the somewhat artificial dichotomy between muscles and movements, between the purpose and its functional basis, and recognize that the activation pattern of motor cortex neurons does two things—it specifies for the peripheral motor system both what to do and how to do it."

Source: Cell Press

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