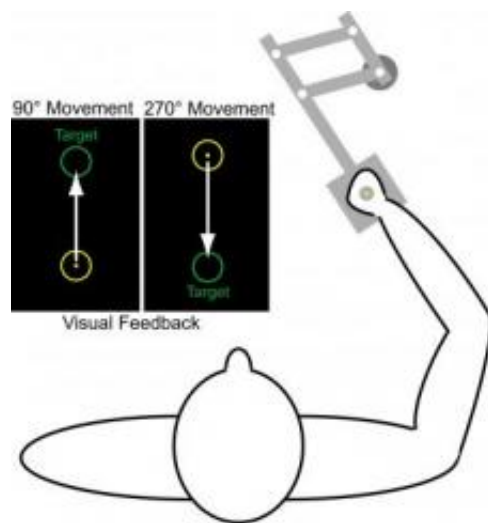


Observation about how nervous system learns and encodes motion could improve stroke recovery

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Subjects were instructed to grasp the handle of a robotic arm and make arm-reaching movements in the 90° and 270° directions. The position of the subject's hand was displayed by a cursor on the screen. Subjects were asked to move the cursor into targets that appeared within 450-550 ms. Credit: Courtesy of the lab of Maurice Smith, Harvard School of Engineering and Applied Sciences

Bioengineers have taken a small step toward improving physical recovery in stroke patients by showing that a key feature of how limb motion is encoded in the nervous system plays a crucial role in how new motor skills are learned.

Published in the November 25, 2009 issue of *Neuron*, a Harvard-based study about the neural learning elements responsible for motor learning may help scientists design rehabilitation protocols in which motor adaptation occurs more readily, potentially allowing for a more rapid recovery.

Neuroscientists have long understood that the brain's primary motor cortex and the body's low-level peripheral stretch sensors encode information about the position and velocity of limb motion in a positively-correlated manner rather than as independent variables.

"While this correlation between the brain's encoding of the position and the velocity of motion is well-known, its potential importance and practical use has been unclear until now," says coauthor Maurice A. Smith, Assistant Professor of Bioengineering at the Harvard School of Engineering and Applied Sciences (SEAS) and the Center for Brain Science in the Faculty of Arts and Sciences.

Smith and colleagues showed that the correlated neural tuning to position and velocity is also present in the neural learning elements responsible for motor learning. Moreover, this correlated drive can explain key features of the motor adaptation process.

To study and record motor adaptation, the researchers had subjects grasp a [robotic arm](#). The device was programmed to simulate novel physical dynamics as subjects made reaching motions. In addition, the team used a newly developed measurement technique called an "error-clamp" to tease apart the resulting data.

The method measures motor output during learning, allowing learning-related changes in motor output over the course of a movement to be dissociated from feedback adjustments that correct motor errors that happen simultaneously.

"Conceptually, this error-clamp is analogous to a voltage-clamp, commonly used in electrophysiology to measure how ions move through a neuron's membrane when it fires," explains lead author Gary C. Sing, a graduate student at SEAS. "The general idea is that devising an experimental method to clamp and control the key variable in an experiment can allow for greater insight into the underlying physiology."

Analysis of the data extracted by the error-clamp technique led to the creation of a computational model that identifies a set of vectors that characterize the principal components of motor adaptation in the state space of physical motion. While such analysis is commonplace in systems engineering—for example, in evaluating how a bridge might react to high winds or earthquakes—the method has only been recently applied to how motor output evolves.

"We observed that the initial stages of motor learning are often quick but non-specific, whereas later stages of learning are slower and more precise," says Sing. "Further, we saw that some physical patterns of movement are learned more quickly than others."

By understanding what types of motor adaptations are easier to learn, the researchers hope to design rehabilitation activities that will encourage patients to use an affected limb more.

"In stroke rehabilitation, patients who make a greater effort to use their impaired limbs can achieve better outcomes," says Smith. "However, there is often a vicious cycle, as a patient is far less likely to use an impaired limb if his or her other limb is fine. This pattern slows recovery and leads to greater impairment of the affected limb."

Smith and his colleagues are beginning studies with [stroke](#) patients to determine whether training them with such optimized patterns will, in fact, improve their rate of motor learning and speed up recovery.

More broadly, untangling the algorithms the brain uses for [motor learning](#) could help improve a wide range of neural and muscular rehabilitation programs. The researchers also anticipate that such findings could be one day be adapted for enhancing the brain/machine interfaces increasingly used for those with amputated limbs.

Provided by Harvard University

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