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Robotic joystick reveals how brain controls movement

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By training a group of human subjects to operate a robot-controlled joystick, Johns Hopkins researchers have shown that the slower the brain "learns" to control certain muscle movements, the more likely it is to remember the lesson over the long haul. The results, the investigators say, could alter rehabilitation approaches for people who have lost motor abilities to brain injuries like strokes.

In a report on the work in the May 23 issue of *PLoS Biology*, the researchers built on their observations that some parts of the brain learn - and forget - fast, while others learn more slowly and more lastingly. Both types of learning are critical.

"We believe our work is the first to show that motor learning involves different time scales and implies that the best strategy in rehabilitating a stroke patient should focus on slow learning because slow-learned motor skills will be maintained longer," says the report's senior author, Reza Shadmehr, Ph.D., a professor of biomedical engineering in the Institute of Basic Biomedical Sciences at Johns Hopkins.

Neuroscientists long have thought that two things are required for mastering such muscle control - time and error. Time refers to the need to "sleep on it," for the brain to somehow process and "remember" how to carefully control muscles. As for error, it's thought that mistakes help the brain and muscles fine-tune fine movements. The requirement for time and error explains why repetition of simple movements day after day is used routinely in rehabilitating partially paralyzed stroke patients and those with other brain injuries.

To test the need for time in mastering muscle control, the research team designed a simple and short task. Fourteen healthy human subjects were asked to hold onto a robot-controlled joystick and keep it from moving as the robot driver pushed repeatedly - in quick pulses - to one side. The joystick then pushed repeatedly in the opposite direction and again the subjects were asked to keep the joystick centered.

The research team found that after all this pushing in different directions the subjects still were inclined to push the joystick in the first direction, even when the joystick was perfectly centered and not moving. Somehow the brain and muscles in the arm had "learned" this simple movement over the course of the experiment, which took only a few minutes, according to the researchers, showing that sleep is not required for learning such simple movements.

The robot-controlled joystick used in these experiments can measure precisely how hard and in what direction it's being pushed by the hand holding it. Using computer programs, the researchers then were able to apply mathematical equations to these measurements and calculate predictions of how the brain might be "learning" these simple movements.

For example, by taking into account the number of repetitions it took for the subjects to push the joystick in the first direction to keep it centered and how long it took for the subjects to "forget" how hard to push the joystick, the predictions suggest that the brain learns muscle control using at least two different steps.

First, the computer programs were able to tease out that the brain picked up the control task quickly, but actually forgot the task quickly as well. But, at the same time, the brain also was learning the same task more slowly, and that was responsible for the subjects' being able to "remember" the initial joystick-pushing movement.

"Rehab is about training, and you want to be able to train the slow-learning system to be successful," says Shadmehr.

As a next step, the team is interested in uncovering which parts of the brain are responsible for slow-learning. They hope that teasing this system apart will not only improve the understanding of brain function, but also tailor therapy strategies to target slow-learning and increase recovery of muscle control after brain injuries.

Source: Johns Hopkins Medical Institutions

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