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On the golf tee or the pitcher's mound, brain dooms motion to inconsistency

Study: Movement not primarily a mechanical phenomenon

BY DAVID ORENSTEIN

If you've ever wondered why your golf swings, fastballs or free throws don't quite turn out the same way each time, even after years of practice, there is now an answer: It's mostly in your head. That's the finding of new research published in the Dec. 21 issue of the journal Neuron by electrical engineers at Stanford University.

"The main reason you can't move the same way each and every time, such as swinging a golf club, is that your brain can't plan the swing the same way each time," says electrical engineering Assistant Professor Krishna Shenoy, whose research includes study of the neural basis of sensorimotor integration and movement control. He, postdoctoral researcher Mark Churchland and electrical engineering doctoral candidate and medical student Afsheen Afshar authored the study.

It's as if each time the brain tries to solve the problem of planning how to move, it does it anew, Churchland says. Practice and training can help the brain solve the problem more capably, but people and other primates simply aren't wired for consistency like computers or machines. Instead, people seem to be improvisers by default.

A major conclusion of the study, in fact, is that movement variability is not primarily a mechanical phenomenon, as had widely been thought. After looking at neural activity and muscle activity, the Stanford researchers concluded that less than half the reason for inconsistency in movement lies in the muscles.

"This is the first study to successfully record neural activity during the planning period and link it on a trial-by-trial basis to performance during those trials," Churchland says.

The Stanford team decided to do just that with the help of rhesus macaque monkeys. The monkeys were trained to perform a simple reaching task. When shown a green spot, they were rewarded with juice if they reached slowly to touch the spot. For a red spot, they were trained to reach fast. During the trials the researchers would monitor the activity of individual neurons in the premotor cortex, a part of the brain responsible for movement planning, while the monkeys were planning their reaches. Then the researchers would record the speed of the resulting motion.

Over a series of thousands of trials, the researchers observed subtle variations in the speeds of the reaches. The monkeys rarely reached with the same exact speed, whether for a green or red spot. More importantly, after some sophisticated statistical processing, the scientists found the small variations in reach speed were predicted by small variations in brain activity during movement planning, before the movement even began.

Flexibility beats consistency

For athletes, the inability to replicate the perfect movement might seem to be a frustrating problem that needs to be solved. But the researchers speculate that the brain has evolved its apparently improvisational style precisely because the vast majority of situations requiring significant movement are novel.

L.A. Cicero

A golfer can't swing a club the same way each and every time because the brain can't plan movement identically each time, according to Shenoy. Here, a golfer practices his swing at the Stanford Golf Course.

Krishna Shenoy

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Predators never get the chance to catch and kill prey in exactly the same fashion and in exactly the same conditions.

"The nervous system was not designed to do the same thing over and over again," Churchland says. "The nervous system was designed to be flexible. You typically find yourself doing things you've never done before."

The value of practice and training is that they can reduce the variation in the mind's abilities, but they don't change the variable way the mind plans motion. An analogy might be to doing math problems. Someone who has studied will find it easier to solve a new problem than someone who has not prepared.

Given the endemic nature of movement variability, the research doesn't point to any definitive means for combating it. In their paper, the engineers offer no advice for baseball trainers to help pitchers throw more strikes. A potential application of the research, Shenoy says, could come in future efforts to achieve new kinds of computing by building artificial circuits modeled on the brain. But Shenoy says the research simply set out to explain variability in movement.

"This is basic science," Shenoy says. "We ask questions because we want to know."

The study could help resolve a question about human nature, however. Which is more true, "nobody's perfect" or "practice makes perfect"? If complete consistency is the standard of perfection, then it seems that nobody will ever be perfect.

David Orenstein is the Communications and Public Relations Manager at the Stanford School of Engineering.

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