The Mysteries of Movement
As you read this article, you might nonchalantly reach over and grab a cup of coffee from the desk or coffeetable. Perhaps without even looking away from the story, you lift the cup, take a sip, and return it to its place.

You probably do this simple act dozens of times each day, without ever thinking about it. Well, think about it. Even the simplest reaching motion takes an extraordinary amount of coordination between your brain, your muscles, and your nervous system.

First, your brain decides what movement to make. Then it sends a command through the nervous system to your muscles. Your muscles begin the process of moving your joints, coordinating motions between your shoulder, elbow, wrist, and fingers. Constant sensory feedback from your arm and hands tells your brain where your arm is in relation to the cup. The brain constantly adjusts its message to the muscles based on this feedback. Eventually, the nerves in your fingers tell your brain, “We’ve hit coffee cup!”

All of this activity happens in a couple of seconds, and sometimes simultaneously while you’re still reading a magazine!

The neuromuscular system is incredibly complex. This complexity allows us to do many things, from drinking coffee to playing the violin or learning karate. Unfortunately, this complexity also makes it difficult to treat or cure people with neuromuscular impairment.

The mysteries of movement are a source of fascination for George Stelmach, a professor of exercise science and director of the Motor Control Laboratory at Arizona State University. Stelmach wants to understand how the brain, nervous system, and muscles work together to move our bodies.

One of the best ways to study how movement occurs is to study what happens when it fails. Stelmach is particularly interested in movement among people with Parkinson’s Disease.

“Most of his studies involve comparing Parkinson’s patients with healthy subjects of the same age. Parkinson’s Disease affects about 1.6 million Americans. It is a neurological disorder with no known cure. The major symptoms include akinesia (inability to initiate movement), bradykinesia (slow movement), rigidity, and tremor. These impairments are well documented. What remains unknown is the mechanism underlying these symptoms. Why do Parkinson’s Disease patients experience these problems?”

Stelmach’s research focuses on the first two symptoms—akinesia and bradykinesia. These have received far less research attention than the more quantifiable symptoms of rigidity and tremor, but they are often the most debilitating features of the disease.

Most of Stelmach’s work to date involves asking Parkinson’s patients to perform such everyday tasks as the coffee-cup lifting described above:

“We try to use tasks that are well-learned and well-practiced, such as reaching and grasping, pointing at a target, or writing/drawing on a digitized pad,” explains Stelmach.

These tasks avoid adding a learning process to the experiment, which might interfere with results. In addition, these activities have been studied extensively among healthy subjects. “There’s a lot of information known about these tasks. The area of motor control is primarily studied in normal people,” says Stelmach.

To study reaching or pointing motions, Stelmach puts markers on the subjects’ fingers, hands, and wrists. Several high-speed cameras detect the locations of the markers throughout the exercise. Later, Stelmach breaks down the task into micro movements to understand the underlying structure of movement.

Stelmach also uses a digitized pad for writing and drawing exercises. The pad measures X and Y coordinates, velocity, and pressure. Some typical exercises include drawing circles, spirals, or simple handwriting. About 20 percent of Parkinson’s patients exhibit micrographia—they start writing words at a normal size and then get smaller and smaller until the writing is almost invisible. Nobody yet knows why this occurs so often among people with the disorder.

Of course, part of the problem with Parkinson’s Disease is that no one knows what causes it in the first place. The lack of information makes treating the disease difficult. Curing the disease remains out of sight for the moment.

What is known is that Parkinson’s Disease involves problems in the basal ganglia, an area of the brain near the brain stem. This portion of the brain is involved in the sequencing of movements in complex, multi-joint activities.

The basal ganglia contain numerous dopamine transmitters. Dopamine is a chemical messenger that transmits signals from one nerve cell to another. The dopamine transmitters in the basal ganglia normally communicate with the motor cortex. In Parkinson’s patients, these transmitters are impaired, sending
irregular, ill-timed, and incomplete messages. “They don’t communicate well with themselves or other parts of the brain,” explains Stelmach. “It’s like a noisy phone line.”

Not surprisingly, one of Stelmach’s research findings is that Parkinson’s patients have trouble controlling multi-joint movements. They also have difficulty using sensory information to make corrections to their movements, something most of us do without even thinking.

Stelmach has also found that Parkinson’s patients have trouble sequencing complex actions. Healthy individuals can activate several joints simultaneously and perform overlapping movements. Parkinson’s patients tend to be more serial, and their movements seem disjointed as a result.

Finally, Stelmach has observed that Parkinson’s patients show differences from the normal velocity of a complete movement.

“Normal subjects show a simple curve in velocity of a movement. In a Parkinson’s patient, the curve ends a little early and is followed by a small second bump. They are making fine adjustments,” he says.

These micro-adjustments take time, which explains why Parkinson’s patients tend to move more slowly than healthy people.

Stelmach’s research results are helping to demonstrate the reasons why Parkinson’s patients exhibit the symptoms they have. But every why question answered often leads to another why?

“The real mystery lies in understanding whether or not movement disorder comes from the brain signal. Is that signal impaired in some way? Or is the secondary information not available or modified? There’s no way to directly separate these two,” says Stelmach.

Stelmach also studies healthy elderly people. He wants to know why older people tend to have impaired coordination in their upper extremities—arms, hands, and fingers. This problem also occurs in Parkinson’s patients.

Elderly people tend to make shorter primary movements and longer secondary movements. They are less able to propel their limbs in a smooth, one-step motion. Stelmach wants to find the reasons for this.

“The experiments are designed to understand this process and try to explain why the movements become disrupted,” he says. “What is it about control from the brain and feedback from the musculature that cause these impairments? The cause of the problem has a profound effect on how you would intervene,” he says.

And intervention is the ultimate goal. Ideally, research such as Stelmach’s will provide the foundation of knowledge needed to develop treatments and cures.

“We’re not just interested in describing the impairment,” he explains. “We want to know how it can be modified. The research doesn’t directly lead to a cure, but indirectly it does. Our findings offer information on the nature of the disease. We’re part of a team, trying to treat and cure Parkinson’s Disease sooner rather than later.”

Research at ASU on Parkinson’s Disease and other movement disorders is supported by the National Institute of Neurological Diseases and Stroke, National Institute on Aging, and the R.S. Flinn Foundation. For more information, contact George E. Stelmach, Ph.D., Department of Exercise Science and Physical Education, College of Liberal Arts and Sciences, 480.965.9847. Send e-mail to steelmach@asu.edu

Moving Toward Answers

Scientists at ASU’s Motor Control Laboratory (MCL) study how the human body gets around. They learn how it plans, organizes, and carries out the business of movement. To gather information, the researchers study the effects of aging and illness on human movement. They also look at the effects of altered environments, such as the low gravity found on a space station orbiting the earth.

“Challenging the motor system gives you the opportunity to study how it adapts,” says George Stelmach, director of the MCL and a professor of exercise science.

The research team includes seven post-doctoral and three graduate students. They all study motor control problems. The ASU scientists have a variety of tools at their disposal. Some of the instruments they use include:

- Eye-tracking equipment
- EMG (electromyographic) equipment that records muscle contraction
- 3-dimensional cameras that record the X, Y, and Z coordinates of markers placed on a subject’s body
- Vision deprivation equipment to study how loss of visual aspects affects movement
- Digitized writing pads that record direction, velocity and pressure

Diane Boudreau
Graduate student Caroline Johnson and George Stelmach. Johnson demonstrates one technique used to study movement. The headset enables a video camera to track the subject's eye direction, while lights on the panel are triggered in various ways to provide targets for hand motion.

An example of writing by a Parkinson’s patient shows micrographia, the characteristic decrease of size that occurs in a sequence of movements.

Researchers in Stelmach’s lab study Parkinson’s with a variety of techniques. Subjects attempt to grasp the bar when its row of lights shines. The row can be changed during the movement, which allows measurement of the subject’s ability to respond to rapid changes of trajectory.

Photographs by John C. Phillips

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