MEANINGFUL MOVEMENT

BRAIN INJURY PATIENT ABLE TO MOVE ROBOTIC ARM WITH THOUGHTS

BY ANITA SRIKAMESWARAN

Like a bashful but determined suitor, 30-year-old Tim Hemmes cautiously maneuvered an unsure hand toward his girlfriend. As their palms touched, tears spilled over onto Katie Schaffer's cheeks, while Hemmes' shined with joy and hope.

The moment was a reminder to the researchers and physicians watching the unfolding drama of why they had been working so hard for so long. Since a motorcycle accident snapped his neck seven years ago, Hemmes hasn't been able to move his body below his shoulders, nor has he had feeling there. Using technology and fundamental understanding of neurobiology advanced by researchers in the University of Pittsburgh School of Medicine, Hemmes guided with his thoughts a robotic arm made by Johns Hopkins University's Applied Physics Laboratory, managing a high five that was a profound illustration of the emotional power, often taken for granted, of touching a loved one.

"We're not just trying to generate movement," says Pitt's Andrew Schwartz, a PhD professor of neurobiology whose experiments in monkeys helped inform the algorithms that were used in this trial of brain-computer interfaces in patients with spinal cord injury.

The ultimate goal is to develop a device that gives paralyzed people the ability to make purposeful movements. The Pitt researchers imagine it would help immobile people perform activities of daily living—like handling a cup and fork or opening doors—and express themselves through gesture—perhaps a welcoming handshake, a jubilant high five, or a tender hug.

Schwartz's monkeys learned to manipulate a robotic arm while their arms were restrained. The monkeys came to see the mechanical arm as their own, licking remaining bits of marshmallow from the grabber after the test tasks were completed, using the grabber to nudge food around in the mouth, and even grooming the metal as they would their own fur.

Schwartz notes that when Hemmes reached out with the prosthetic arm, "you really did start to sense that, for instance, his girlfriend had taken this as an embodied hand of Tim's, and was actually feeling the extension of Tim's body scheme to that hand."

Michael Boninger, an MD professor and chair of Pitt's Department of Physical Medicine and Rehabilitation, describes a brain-computer interface as a device that taps into thoughts so they can be translated into action. The grid being used in the trial grew out of electrocortigraphy (ECoG), a technique in which electrodes are placed directly on the brain to study brain signals (often to help doctors pinpoint cortical areas in the brain that set off seizures). The grid sits on the surface of the brain, gathering neuronal signals from the motor cortex mapped to where Hemmes imagined and observed arm movement. In a Pitt pilot study led by Elizabeth Tyler-Kabara, an MD/PhD assistant professor of neurological surgery, and Wei Wang, MD/PhD assistant professor of physical medicine and rehabilitation, epilepsy patients admitted for seizure-mapping tested the grid. In that study, volunteer patients raised their eyebrows, flexed their elbows, or made other specific movements to send signals through the grid to a computer processor, enabling them to move a cursor on a computer screen or take Super Mario through an adventure. The results of this pilot project paved the way for techniques in patients with spinal cord injury.

Hemmes, the high-fiving patient, was first charged with the task of moving one ball to touch another on a computer screen. Soon, his commitment to the project and his own desire to best his previous "score" had him quickly progressing from two-dimensional movements of up-down and right-left to moving the ball "in and out" on a 3D TV screen. He worked with the arm only a few times during the 28-day study protocol. The high five with Schaffer happened after he'd done the same thing with lead researcher Wang—in part, to celebrate the end of nearly daily data collection.

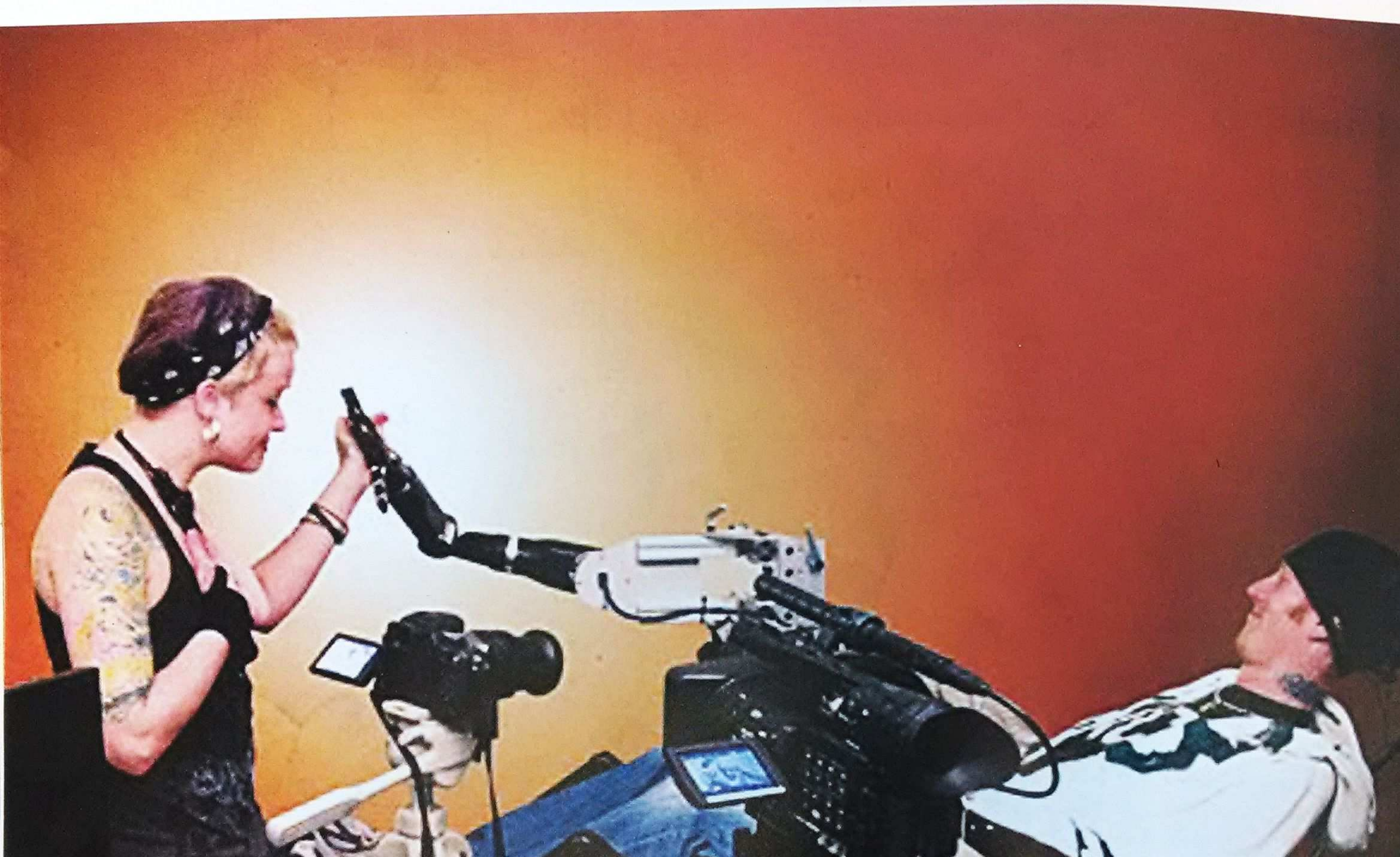
"When you plan an experiment, you always picture it," Boninger said. "What you can't picture really is the human factor. Seeing [Hemmes'] face light up as well as those of the amazing team of investigators that were working with him was quite a spectacular sight."

This year, more participants will be enrolled in the ECoG-based protocol. In tandem, the team will start a yearlong trial to test another kind of brain-computer interface, a 10-by-10 microelectrode array that barely penetrates the brain to pick up signals from hundreds of neurons in the motor cortex; it's the same type of interface that Schwartz has been using in the monkey experiments. Tyler-Kabara will implant two grids in each participant: one in the area mapped for arm movement and the other for the hand. The higher-signal resolution could allow greater control of the arm, including the fingers, and a full exploration of its potential.

Then, they hope to make the device wireless and add sensors to the arm to deliver signals to the brain and recreate sensation.

Hemmes' achievement has validated conclusions reached after 20 years of studying neural signaling and motion, Schwartz says. And, he notes, now hundreds of people are working toward moving the technology forward from what his small group started.

"That's really satisfying," Schwartz adds. ■



For the first time in seven years, Tim Hemmes touches his girlfriend's hand; to do so, Hemmes uses a robotic arm he controls with his thoughts.