

Brain linked to robotic hand; success hailed

By David Templeton
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When it happened, emotions flashed like lightning.

The nearby robotic hand that Tim Hemmes was controlling with his mind touched his girlfriend Katie Schaffer's outstretched hand.

One small touch for Mr. Hemmes; one giant reach for people with disabilities.

Tears of joy flowing in an Oakland laboratory that day continued later when Mr. Hemmes toasted his and University of Pittsburgh researchers' success at a local restaurant with two daiquiris.

A simple act for most people proved to be a major advance in two decades of research that has

SEE **ROBOTICS**, PAGE A-5

Brain signals succeed in moving robot arm

ROBOTICS, FROM PAGE A-1

proven to be the stuff of science fiction.

Mr. Hemmes' success in putting the robotic hand in the waiting hand of Ms. Schaffer, 27, of Philadelphia, represented the first time a person with quadriplegia has used his mind to control a robotic arm so masterfully.

The 30-year-old man from Connoquenessing Township, Butler County, hadn't moved his arms, hands or legs since a motorcycle accident seven years earlier. But Mr. Hemmes had practiced six hours a day, six days a week for nearly a month to move the arm with his mind.

That successful act increases hope for people with paralysis or loss of limbs that they can feed and dress themselves and open doors, among other tasks, with a mind-controlled robotic arm. It's also improved the prospects of wiring around spinal cord injuries to allow motionless arms and legs to function once again.

"I think the potential here is incredible," said Dr. Michael Boninger, director of UPMC's Rehabilitation Institute and a principal investigator in the project. "This is a breakthrough for us."

Mr. Hemmes? They say he's a rock star.

Reading brain signals

In a project led by Andrew Schwartz, Ph.D., a University of Pittsburgh professor of neurobiology, researchers taught a monkey how to use a robotic arm mentally to feed itself marshmallows. Electrodes had been shallowly implanted in its brain to read signals from neurons known to control arm motion.

Electrocorticography or ECoG — in which an electronic grid is surgically placed against the brain without penetration — less intrusively captures brain signals.

ECoG has been used to locate sites of seizures and do other experiments in patients with epilepsy. Those experiments were prelude to seeking a candidate with quadriplegia to test ECoG's capability to control a robotic arm developed by Johns Hopkins University.

The still unanswered question was whether the brains of people with long-term paralysis still produced signals to move their limbs.

ECoG picks up an array of brain signals, almost like a secret code or new language, that a computer algorithm can interpret and then move a robotic arm based on the person's intentions. It's a simple explanation for complex science.

Mr. Hemmes' name cropped up so many times as a potential candidate that the team called

him to gauge his interest.

He said no. He already was involved in a research in Cleveland and feared this project would interfere. But knowing they had the ideal candidate, they called back. This time he agreed, as long as it would not limit his participation in future phases of research.

Mr. Hemmes became quadriplegic July 11, 2004, apparently after a deer darted onto the roadway, causing him to swerve his motorcycle onto gravel where his shoulder hit a mailbox, sending him flying headfirst into a guardrail. The top of his helmet became impaled on a guardrail I-beam, rendering his head motionless while his body continued flying, snapping his neck at the fourth cervical vertebra.

A passer-by found him with blue lips and no signs of breathing. Mr. Hemmes was flown by rescue helicopter to UPMC Mercy and diagnosed with quadriplegia — a condition in which he had lost use of his limbs and his body below the neck or shoulders. He had to learn how to breathe on his own. His doctor told him it was worst accident he'd ever seen in which the person survived.

But after the process of adapting psychologically to quadriplegia, Mr. Hemmes chose to pursue a full life, especially after he got a device to operate a computer and another to operate a wheelchair with head motions.

Since January, he has operated the website — www.Pittsburghpitbullrescue.com — to rescue homeless pit bulls and find them new owners.

The former hockey player's competitive spirit and willingness to face risk were key attributes. Elizabeth Tyler-Kabara, the UPMC neurosurgeon who would install the ECoG in Mr. Hemmes' brain, said he had strong motivation and a vision that paralysis could be cured.

Ever since his accident, Mr. Hemmes said, he's had the goal of hugging his daughter Jaylei, now 8. This could be the first step.

"It's an honor that they picked me, and I feel humbled," Mr. Hemmes said.

Mental gymnastics

Mr. Hemmes underwent several hours of surgery to install the ECoG at a precise location against the brain. Wires running under the skin down to a port near his collarbone — where wires can connect to the robotic arm — caused him a stiff neck for a few days.

Two days after surgery, he began exhaustive training on mentally maneuvering a computer cursor in various directions to reach and make targets disappear. Next he learned to move the cursor diagonally

before working for hours to capture targets on a three-dimensional computer.

The U.S. Food and Drug Administration allowed the trial to last only 28 days, when the ECoG is removed. The project, initially funded by UPMC, has received more than \$6 million in funding from the Department of Veterans Affairs, the National Institutes of Health, and the U.S. Department of Defense's Defense Advanced Research Projects Agency, known as DARPA.

Initially Mr. Hemmes tried thinking about flexing his arm to move the cursor. But he had better success visually grabbing the ball-shaped cursor to throw it toward a target on the screen. The "mental eye-grabbing" worked best when he was relaxed.

Soon he was capturing 15 of 16 targets and sometimes all 16 during timed sessions. The next challenge was moving the robotic arm with his mind.

The same mental processes worked, but the arm moved more slowly and in real space. But time was ticking away as the experiment approached its final days last month. With Mr. Hemmes finally moving the arm in all directions, Wei Wang — assistant professor of physical medicine and rehabilitation at Pitt's School of Medicine who also has worked on the signaling system — stood in front of him and raised his hand.

The robotic arm that Mr. Hemmes was controlling moved with fits and starts but in time reached Dr. Wang's upheld hand. Mr. Hemmes gave him a high five.

The big moment arrived. Katie Schaffer stood before her boyfriend with her hand extended. "Baby," she said

encouraging him, "touch my hand."

It took several minutes, but he raised the robotic hand and pushed it toward Ms. Schaffer until its palm finally touched hers. Tears flowed.

"It's the first time I've reached out to anybody in over seven years," Mr. Hemmes said. "I wanted to touch Katie. I never got to do that before."

"I have tattoos, and I'm a big, strong guy," he said in retrospect. "So if I'm going to cry, I'm going to bawl my eyes out. It was pure emotion."

Curing paralysis

Mr. Hemmes said his accomplishments represent a first step toward "a cure for paralysis." The research team is cautious about such statements without denying the possibility. They prefer identifying the goal of restoring function in people with disabilities.

"This was way beyond what we expected," Dr. Tyler-Kabara said. "We really hit a home run, and I'm thrilled."

The next phase will include up to six people tested in another 30-day trial with ECoG. A year-long trial will test the electrode array that shallowly penetrates the brain. Goals during these phases include expanding the degrees of arm motions to allow people to "pick up a grape or grasp and turn a door knob," Dr. Tyler-Kabara said.

Anyone interested in participating should call 1-800-533-8762.

Mr. Hemmes says he will participate in future research.

"This is something big, but I'm not done yet," he said. "I want to hug my daughter."

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