

CYBER SNACKING

At the University of Pittsburgh Motorlab, you can see a monkey, its neural activity monitored and recorded by a tiny microelectrode array, feed itself marshmallows using a robotic arm rather than its hands.

When the monkey thinks of grabbing the food—presented to it at the end of a metal spindle—the microarray feeds the monkey's thought of using the robotic arm into a computer, which processes the information and feeds it to the arm. With almost no lag time, the monkey's thoughts cause the arm to reach out, grab the food, and bring it back to the monkey's mouth, at which point the primate stuffs the treat into its maw.

It's kind of nuts to watch. And yet it makes perfect sense: If you can find the neurons responsible for motor activity, you can figure out how these neurons communicate, and then, eventually, find a way to translate the signals to drive motion in a robotic arm. Pretty simple, conceptually. It's not at all simple, though, technologically speaking.

Pitt professor of neurobiology Andrew Schwartz is, in concert with Michael Boninger, Pitt professor and chair of the Department of Physical Medicine and Rehabilitation, edging this technology toward prime time at the University of Pittsburgh.

"We started thinking seriously about this in 1986," Schwartz, a PhD, says. "That was when we could demonstrate that we could decode these signals reliably from the brain. Once we had the data, we knew it could work."

A quarter century since he "knew it could work," Schwartz has surmounted many of the technological hurdles and is pressing ahead.

On a typically inclement early March day in Pittsburgh, technicians assisting Schwartz are less concerned with the weather than the installation and calibration of a remarkably expensive, brand-new robotic arm. The \$400,000 device (the Defense Advanced Research Projects Agency—DARPA—has spent tens of millions of dollars on this research and technology so far) was built at the Johns Hopkins University Applied Physics Laboratory.

Looking like it might have fallen off RoboCop, the arm is mounted on a floor-to-ceiling pole in a small room, off a larger space packed with computers. A group of youngish men studying under Schwartz and a rep from

the Applied Physics Laboratory surround it, fiddling with the device.

"This project was designed to be a prosthetic arm that goes on an amputee," Schwartz says as the work goes on. "It weighs nine pounds, so it weighs as much as a regular arm. It has the size of a regular arm and hand, and it can do things like lift 50 pounds." Also, Schwartz adds, the fingertips of the device have sensors that will offer users tactile feedback. Eventually. That's something that still needs to be sorted out.

(The technology Schwartz has developed has been featured on *60 Minutes* and in *The New York Times*, among other media outlets. This magazine ran a February 2005 feature, "Cyborg Medicine.")

While Schwartz is the lead brain behind the arm's technology, Michael Boninger, an MD and director of the UPMC Rehabilitation Institute, will lead the about-to-begin clinical trials.

Boninger is recruiting people with quadriplegia from spinal cord injuries for the trial. The group considered others with no use of their arms, such as people with amyotrophic lateral sclerosis, but thought the progressive nature of the disease would complicate the study.

The first trial, Boninger says, will further investigate the most effective way to record electrical signals from the brain. Each patient will have an array of 16 electrodes laid on the brain surface and then be instructed to move a cursor on a computer screen and, eventually, manipulate a prosthetic arm in a simple way while the array records neural activity. The trial will last about a month.

The second trial will last one year and

will study how well participants can perform functional tasks with the arm, which will be mounted to a wheelchair. More sensitive arrays—each with 100 electrodes—will actually be implanted into the patient's brain rather than laid on the surface.

"We'll have much more time to train them and much more time to get participants to use the arm with multiple degrees of freedom," Boninger says. "I would hope that by the end of the year, they'll be able to do things so well with the arm that it will be of some practical assistance to them."

The trial is expected to begin late this year. It and the briefer trial are supported by \$6.8 million in grants from DARPA and the National Institutes of Health.

No matter how well the trials work and how much is learned, Schwartz says, there's much to be done before his group can offer a commercially viable product.

"Well, it's one thing to demonstrate this in a lab, but will it be reliable enough to use every day? The machinery can break down a lot, then there's the issue of how long the [microarray] implants can stay in; the brain tries to reject them and encapsulate them," Schwartz says. "We'd like to have bilateral control [the ability for the brain to control two robotic arms simultaneously], but we don't know how that's going to work, and we're not sure how well you'd be able to move individual fingers ..."

"And one of the most critical factors is the patient's ability to learn. What I mean is that we're recording their neural activity, and they're trying to get their neurons to work this device. So they're trying to make their neurons fit our expectations."

THE THINKING WHEELCHAIR'S WHEELCHAIR

Equipped with robotic arms, which can lift a few pounds each and have dexterity enough to lift a magazine off a table, the Personal Mobility and Manipulation Appliance (PerMMA) is being prepped for clinical trials—and is being continually refined—at the Human Engineering Research Laboratories (HERL) at the VA Pittsburgh Healthcare System—Highland Drive. (The lab, affiliated with the University's School of Health and Rehabilitation Sciences, is moving to new space at Pittsburgh's Bakery Square development, also home to a Google campus, in July.)

Early one morning, Garrett Grindle, a graduate student researcher at HERL, and Juan Jose Vazquez, a research associate, were sitting with PerMMA in lead developer Rory Cooper's office, prepared to put it through its paces. Cooper is professor of orthopaedic surgery in the School of Medicine and FISA & Paralyzed Veterans of America Chair and Distinguished Professor of