Mind Over Matter: Brain Waves Guide a Cursor's Path

Biomedical Engineers Create Devices That Turn Thoughts Into Action and Could Help the Paralyzed Move Their Limbs

By RICK WEISS
Washington Post Staff Writer

Scott Hamel is a tough guy. In the gym, people stare in awe as he bench-presses more than 250 pounds. On the race track, he thinks nothing of taking his customized Corvette up toward the 200 mph mark.

Yet twice a week or so, Hamel puts on an adorable red bonnet decorated with white polka dots and fastens its strap under his chin. He does so to exercise what has become the most powerful muscle in his body: his mind. With the help of that bonnet—actually a high-tech piece of headgear that is wired to equipment developed by scientists in Albany, N.Y.—Hamel has learned how to move a cursor around on a computer screen just by thinking about it.

Hamel is one of four people whose techno-telepathic powers were highlighted last week in a scientific report that broke new ground in the rapidly advancing field of "brain-computer interfaces." Neuroscientists and biomedical engineers in that specialty have become increasingly adept at making devices that translate people's thoughts into actions—a potential boon for paralyzed patients. But the newest and reputedly most promising of those systems have been dependent on wire electrodes implanted directly into the brain, presenting risks of infection and other complications.

By contrast, the cap that Hamel has been test-driving picks up on brain waves emanating from his skull. With it, he can send computer cursors on various trajectories and zap targets as they appear on a screen, using nothing more than a series of mental impulses.

"People have assumed you'd have to put electrodes in the brain to get this level of control," said lead researcher Jonathan Wolpaw, chief of the nervous system disorders lab at the state health department's Wadsworth Center. "But noninvasive methods can be a lot better than people have given them credit for."

Wolpaw's "thinking cap" sports 64 sensors (the polka dots) that detect electroencephalographic (EEG) signals generated by neurons. With a software program analogous to those used in voice-recognition programs, which "learn" people's verbal quirks over time, people can gain control over a cursor's movement in two dimensions by modulating signal intensities in certain regions of the brain, Wolpaw and co-worker Dennis McFarland reported in last week's early online edition of the Proceedings of the National Academy of Sciences.

Hamel, for example, makes a cursor move up by getting his brain to generate strong 24 cycles-per-second signals in two areas of the sensorimotor cortex, the region that normally controls limb movements. Weakening that signal moves the cursor down. He pumps up a 12 cycles-per-second signal on the right side of his brain and weakens the equivalent signal on the left to move the cursor right, and does the reverse to move it left.

Of course, he is not thinking about brain-wave patterns any more than he does when brushing his teeth. He just tries to connect with the cursor.

"It's like when a basketball player is in the zone," said Hamel, 43, who lives in Averill Park near Albany. "It's him and the ball and the basket, and there's no one else there. That's what it's like."

After a few months of 30-minute training sessions four or five times a week, he and the three other volunteers were able to zap targets within a couple of seconds after they appeared at random spots on the screen. That suggests the technology may prove invaluable for quadriplegics and others lacking the ability to use their hands or voices.

Hamel can empathize with them. He has been paralyzed below the chest since he was in a car crash at age 16 (one ironically unrelated to drag racing, which he was already dabbling in at the time). With his nervous system intact from the chest up, he does not need special technology to communicate or to use a computer. But out of personal interest and a desire to help others, he has worked with Wolpaw for years, since answering a call for volunteers posted at the gym.

The degree of control that Hamel and others have attained impresses many scientists, but many suspect the technology will never match the results being obtained with electric leads in the brain.

"EEG is fine if you only want to move a cursor," said Miguel Nicolelis, a Duke University researcher who has been implanting hundreds of electrodes into monkeys' brains, allowing them to operate robotic arms with their thoughts. "But to really restore motor function, to give mobility to a patient's own limbs, you need more control than that. You need to get into the brain."

Dawn Taylor, a biomedical engineer at Case Western Reserve University and the Cleveland VA Medical Center, agrees. "The deeper you go into the brain, the better the recording quality and the more signal you can get out," Taylor said. She is developing a system to send brain signals to stimulators wired to paralyzed people's muscles, perhaps allowing them to use their limbs again by making those muscles twitch in coordinated fashion.

Still, Taylor said, some people who might benefit from more invasive systems may settle for cruder EEG control. "A lot of people are just not going to agree to have stuff put in their head, and that's understandable. Different people have different tolerances for being the next cyborg," she said. "And for those who just want to communicate with a caregiver and work the computer, [EEG] is a good step forward."

Implanted electrodes are already being tested in a few people. A device that packs 100 wire sensors in a pellet the size of a baby aspirin has been implanted in one patient and will soon go into four others under a Food and Drug Administration-approved study led by John Donoghue of Brown University and Cyberkinetics of Foxborough, Mass. That device is expected to allow disabled people to operate a computer and a robotic limb.

Others, including neurobiologist Andrew Schwartz of the University of Pittsburgh School of Medicine, are focusing on translating brain patterns into seamless three-dimensional actions. "My goal is to get a prosthetic to work so it doesn't look like a robot moving but like a person moving, with all the agility of the human arm."

If new computer programs can tell what a brain wants a cursor to do, can mind-reading technology be far behind?

Don't hold your breath, Taylor advised. Fleeting thoughts are much more difficult to analyze than focused commands such as "Go up!" or "Go down!"

Today's programs may detect brute-force commands, Taylor said, "but it's not like we're reading your deepest secrets here."

Maybe not. But here is an EEG signal for any machine that might be trying: "MYOB!"

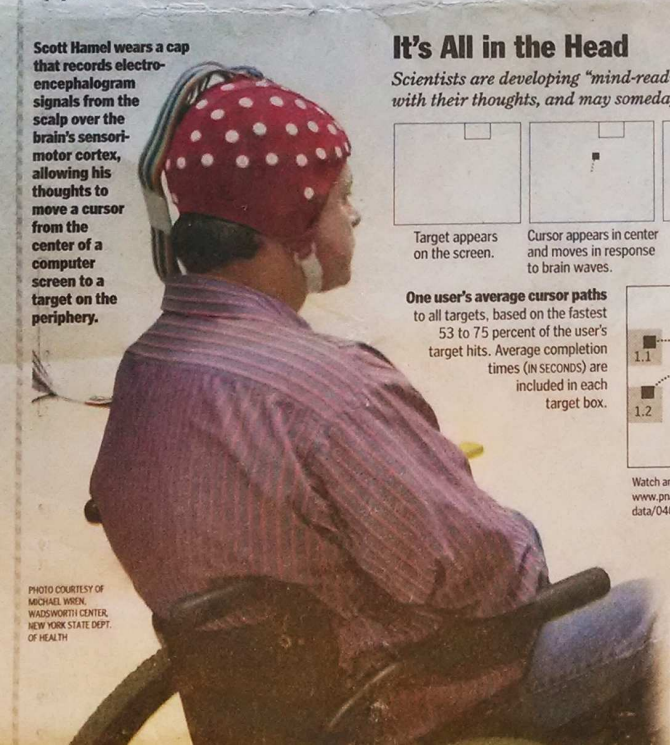
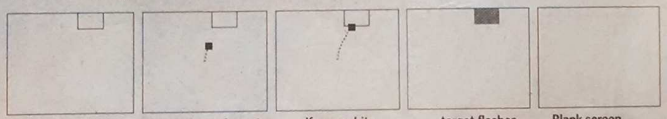


PHOTO COURTESY OF MICHAEL WREN, WADSWORTH CENTER, NEW YORK STATE DEPT. OF HEALTH

Scott Hamel wears a cap that records electroencephalogram signals from the scalp over the brain's sensorimotor cortex, allowing his thoughts to move a cursor from the center of a computer screen to a target on the periphery.

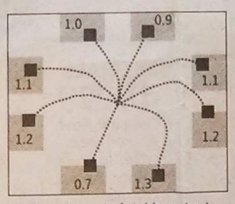
It's All in the Head

Scientists are developing "mind-reading" systems that allow people to control computers with their thoughts, and may someday help the disabled operate mechanical arms or legs.



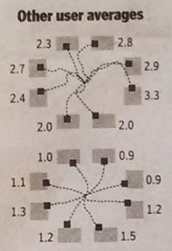
Target appears on the screen. | Cursor appears in center and moves in response to brain waves. | If cursor hits the target... | ...target flashes and disappears. | Blank screen before next trial.

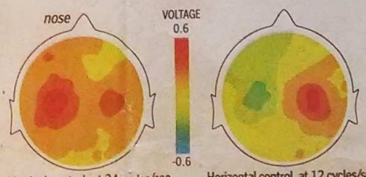
One user's average cursor paths to all targets, based on the fastest 53 to 75 percent of the user's target hits. Average completion times (IN SECONDS) are included in each target box.



Watch an online movie of a training session at www.pnas.org/content/vol0/issue2004/images/data/0403504101/DC1/03504Movie1.mov

Other user averages





Vertical control, at 24 cycles/sec. | Horizontal control, at 12 cycles/sec.

EEGs of a brain activity moving a cursor up and to the right.

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