PROFESSIONAL ISSUES

Rewiring lives (book excerpt: *Shattered Nerves*)

New medical devices are offering hope for patients to hear, see and move their limbs. New York science and technology writer Victor D. Chase tells how.

By Victor D. Chase, *AMNews* contributor. Feb. 12, 2007.

This excerpt shows how one system might help some people with disabilities operate a computer through brain waves.

Book Excerpt
A peek inside what's new on the shelves on topics pertinent to physicians.

Scott Hamel is an automotive teaching assistant, who at 140 pounds held the bench press record for his weight class in New York state at one time by lifting almost twice his weight. Hamel also drives drag racers and owns his own drag race team. And he is a paraplegic, paralyzed in an automobile accident in 1977, when he was a junior in high school. But is he concerned about the danger involved in barreling down a drag strip at 200 miles per hour? "I never give it a thought," Hamel said. One thing he gives a lot of thought to, however, is operating a computer, which is something he does regularly, using his thoughts and nothing else.

On a bright, warm summer day, Hamel sits alone in his wheelchair in a darkened room in the massive Empire State Plaza in Albany, where the business of New York state is conducted and where the offices and laboratories of the State Health Dept. are located. He is wearing a bright red cloth hat, looking much like a shower cap, chin strap and all, except that it includes 64 small, white round dots symmetrically spaced across its surface, each representing an electrode that contacts the outside of his skull. Wires from the electrodes merge into a flat cable that leads to a computer on a table behind Hamel. Not moving a muscle, he is totally engrossed in the image on the monitor five feet in front of him as it responds to his thoughts, which are focused on moving the computer's cursor to a red oblong box that has just popped up in one corner of the screen. The other corners are populated by green boxes. It is Hamel's task to think the cursor to the red box, which requires moving the cursor up and down and side to side. When he successfully makes contact, the red box turns yellow and a new set of boxes

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appears. Where the red box will show up is arbitrary and differs each time the image changes. The faster he hits the target, the faster the screen configuration changes. If he does not reach the red target after a few seconds, the screen goes blank and a new set of targets appears. During the first of a series of three-minute sessions, Hamel hits 20 out of 27 red targets. His score is similar for the other six sessions.

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Unlike other systems, which utilize electrodes implanted in or on the brain to operate a computer with captured brain waves, the noninvasive brain-computer interface (BCI) system Hamel is testing records brain waves from outside his skull, using the same EEG technology that has been used as a diagnostic tool by the medical profession since the early 1900s. Electroencephalography was invented in the 1920s by the German psychiatrist Hans Berger, who used his 15-year-old son Klaus as a test subject. But it is highly unlikely that either father or son ever dreamed of the use Hamel is now making of the technology.

After demonstrating his dexterity, Hamel apologized for not doing as well as he had hoped. "On days I come in when I'm flying high, I will knock out 30 to 34 targets at over 90%," said the young-looking 44-year-old.

Trying too hard to think a cursor into motion is counterproductive, which is what prevented Hamel from doing his best during the demonstration. Because he wanted to do particularly well for a visitor, he did not feel as relaxed as usual. And once things didn't go as he had hoped, frustration set in, causing further tension. "Some days I come in here, I stayed up late, and I'm almost sitting in the chair taking a nap, and the cursor will fly all over the place wherever I want it to go," said Hamel. "I don't have to think about it. Other days, if I've had a tough day before I come here and my brain is very busy, or I get into a situation like I had today, it is a little bit of a struggle. It is the art of relaxing. On days I'm relaxed, and I don't give a damn if I hit the target or not, it just goes. It's like a basketball player when he can't miss a basket. He's just banging those baskets out. I find that zone; all of a sudden it's there. It flies."

The inventor of EEGs used his son as a test subject.

The BCI system Hamel is testing was developed by Jonathan R. Wolpaw, [MD] chief of the Laboratory of Nervous System Disorders of the New York State Dept. of Health's Wadsworth Center. Wolpaw graduated from Case Western Reserve Medical School in 1970 and trained as a clinical neurologist before he decided to devote himself full-time to research. In what has become a virtual rite of passage for neural prosthetic researchers, he spent several years early in his career working at the NIH. It was there that he began his work on recording brain signals, first using the noninvasive EEG approach and then recording from the brains of monkeys implanted with electrodes. He also became skilled at using noninvasive EEG signals for therapeutic purposes, especially for biofeedback to help epileptics control the frequency of their seizures and for headache sufferers to control the intensity of their pain. From the NIH, and following a stint in the Army, Wolpaw moved to the New York State Dept. of Health, when in the mid-1980s, IBM and New York state began a joint project to develop new ways of using computers to assist people with disabilities.

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The next excerpt explores the ethics of using implants to enhance the abilities of able-bodied people.

Once the hurdles of research, human testing, and regulatory approval are surmounted and neural prostheses become a commonplace treatment for disabilities, as they likely will, the question arises as to whether they can and should be used to enhance the abilities of able-bodied individuals as well. And if brain enhancement implants become available, who should receive them? Who among us would not want the pilot of the airplane you are flying on to have enhanced reflexes or the surgeon performing a complex procedure on you to have a keener sense of sight and more intense powers of concentration than one who was not enhanced?

Many recoil at the thought of someone having a foreign object implanted in his or her perfectly healthy brain, but such procedures might well become culturally acceptable. Consider, for example, that during the 17th century, the idea of surgically violating the body was abhorrent. Now, people have elective surgery to improve their looks and no one blinks an eye. And some argue that we already manipulate our brains with alcohol and mood-altering drugs, such as Prozac, Paxil, and Zoloft, not to mention illegal recreational drugs.

Most bioethicists who contemplate the question of enhancement focus on pharmaceuticals, but they do not consider the moral questions implicit in brain implantation to be much different. And surprisingly, some leading bioethicists do not have a problem with the idea of enhancement of the able-bodied.

"I'm not sure whether it will be drugs or devices, but things are coming in both areas," said Arthur Caplan [PhD, a bioethicist in Pennsylvania]. "What works for people with illnesses will work for people who are normal, most likely to add ability. I don't have a moral problem with that per se. Some argue it's just unnatural to give people capacities more than what they were born with. I think that's exactly what we do in education and training, and libraries, and computers, so I'm not moved by that argument."

But Caplan cautioned that enhancement of the able-bodied must be done on a voluntary basis, without coercion. If a child is implanted with a chip in the brain that will make him or her a good violinist because that is what the child's parents want, that's bad. On the other hand, if one's memory is boosted, or an individual is given enhanced reflexes or an extended sense of smell by means of implantation and can choose whether to use the enhancements, that's fine with Caplan. "To me the right stance is enhancement is acceptable if you can improve and enhance people's abilities, but they still retain the right to reject them." This, he pointed out, is in keeping with what goes on in current culture, in which "many people today don't choose to use the brains they have."

What does concern Caplan about enhancement of the able-bodied is that it has the potential to broaden the existing gap between the haves and have-nots of the world. "It's not the technology; it's the inequity that's the problem. It's the money and access issue," he said.

As for the potential risks involved in implantation, Caplan thinks people should be able to decide for themselves if the risk is worth the reward. But as a practical matter, he feels the medical community will limit the risk: "Strange as it may seem, the moral boundary will probably be set by medicine saying anything

more than minimally risky odds can't be taken just for enhancement purposes. I think most responsible doctors won't do it, but there will be some who will. And we will be debating them as renegades and morally questionable people in 30 or 40 years."

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ADDITIONAL INFORMATION:

Author Q&A

How have patients benefited from neural prosthetics?

Unbeknownst to each other, virtually all of the patients I interviewed, regardless of their disabilities and the implants they received, used virtually the same words to describe their feelings. In one way or another, each said, "Something is better than nothing." Beyond benefiting from the sometimes limited abilities their prosthetics impart, they have positive feelings about being a part of the teams that are developing these devices. They also derive an altruistic satisfaction from the fact that they may well be helping future generations of people with similar maladies. It seems to give their suffering a greater purpose. I think physicians should keep the psychological benefits of implantation in mind when contemplating whether to recommend neural prosthetics to their patients as they become more widely available.

What technological advance will be used next in medicine?

My estimation is that functional electrical stimulation systems, designed to return movement to the paralyzed, will be the next facet of neural prostheses to gain widespread clinical acceptance. In fact, the Freehand, which includes eight strategically implanted electrodes that allow quadriplegics to manipulate a hand, was approved for clinical use by the FDA in 1997, and was commercially produced for several years before being taken off the market for business, as opposed to technical, reasons. During that period, it was implanted in hundreds of people. The inventors of that system at the Cleveland Functional Electrical Stimulation Center are developing newer versions of that system with more electrodes and improved actuation configurations. They are also working on using many of the same components to create standing and stepping systems for paraplegics, which are currently being tested in humans.

Why is it important for physicians to know about these state-of-the-art medical devices?

There is a series of weapons about to be added to their arsenal of treatments for those whose conditions were heretofore untreatable. That they someday, hopefully soon, will be able to offer hope of improvement, however little, to those who essentially had none before. Maybe these kinds of things will make

physicians think long and hard before telling people who have been injured in such devastating ways that their life as "normal" people is over. This allows some hope, as long as it's given with a dose of reality. The longer we go in time, the more real these things will become, and with the proper funding, they can be put into clinical use. With any kind of technological development, some of it's going to work and some of it's not going to work.

Interview by reporter Damon Adams

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