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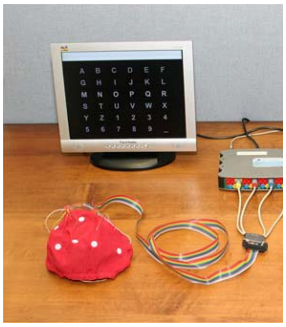
Linking NIBIB-supported research to improvements in health

Brain-Computer Interfaces Come Home: November 28, 2006

Amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease) and other debilitating neuromuscular diseases make it difficult, and in many cases impossible, for people to communicate. In the case of ALS, people may retain normal cognitive function, but they eventually lose all ability to use muscles and cannot communicate by speech, nodding, or even eyeblinks or eyegaze.

For almost 20 years, researchers at the Wadsworth Center, New York State Department of Health, in Albany, New York, have been developing a brain-computer interface (BCI) system that helps paralyzed people to communicate. "Communication is a critical problem for many people with ALS," says Gerwin Schalk, chief software engineer of the Wadsworth BCI project. "If they can communicate, they may be able to live productive and fulfilling lives."

The Wadsworth Brain-Computer Interface project, headed by Dr. Jonathan R. Wolpaw, has created the Wadsworth BCI system which records the brain's electrical activity using electrodes attached to a cap worn by the user. These signals are analyzed and translated by computer into useful device commands. The system allows users to perform word processing, write e-mails, select computer icons, or move a robotic arm. Since the brain signals are recorded by EEG, no surgery is required.



A laptop computer and redesigned ca
BCI's portability and ease of use. *C*
Project

The Mind Speaks

For Scott Mackler, an NIH-funded neuroscientist at the University of Pennsylvania with late-stage ALS, the Wadsworth BCI has enabled him to continue his research. "I couldn't work independently without it," he wrote in an email. Mackler, who has used the system since February, responded to questions for this artic
his brain waves, about two to four words per minute.

In the typing mode, the system allows Mackler to choose from a matrix of letters, numbers, and function codes like those found on a co
to spell a word, he concentrates on a particular letter while the lines and columns of letters flash in sequence. The system records Mac
translates them into the letter he wishes to use. The letter is displayed on the computer screen. The process begins again for him to sel

Mackler uses the system to send email and to communicate with colleagues. The system also has a speech mode to produce predefine
"I'm hungry." "The system is easy to use," writes Mackler who mastered the system the first day he got it. Prior to using the Wadsworth
eyetracker system but found it unreliable as his disease progressed.

Refining the System

For the past year, the Wadsworth team has worked intensely to move the BCI system from the laboratory to home use. In 2005, the group was the winner of the Altran Award for Innovation which provided a year of consulting services by Altran companies. As a result, Cambridge Consultants, Inc., Boston, Mass., helped the group redesign the cap that houses the EEG electrodes to make it comfortable to wear for long periods and helped the group simplify the software on the user end.

The streamlined version of the Wadsworth BCI relies on a laptop computer, a portable amplifier, and the breathable cap which contains just 8 electrodes, down from the original 64. The software program that drives the system can now be easily initialized and monitored by a caregiver. The cost of the system is currently about $4,000 and Wolpaw expects the cost to drop in the future.

Mark Manasas, manager for surgical and interventional devices at Cambridge Consultants, Inc., notes that the new cap makes it easy to place the electrodes properly. Repeat placement is important for optimal results since particular brain waves are used. One of the items on Scott Mackler's wish list is the use of dry electrodes on the cap since a caregiver must apply electrode gel to each electrode every time the cap is worn. The gel allows the electrodes to make good contact with the user's scalp. Dry electrodes are under development, but models currently available do not reliably record the brain signals used for BCIs. "The signals are so small that they get lost in background noise," says Manasas.

Another improvement in the Wadsworth BCI is a smaller amplifier, now about the size of a cordless phone. The old amplifier was the size of a CPU tower. The Wadsworth team worked with g-tech, an Austrian electronics company, to achieve this. "The goal is to reduce the size of the entire system so that it can be mounted on a wheelchair," says Wolpaw.

In the word processing mode a user concentrates o
lines and columns of letters flash in sequence. The s
brain waves and translates them into the chosen lett
on the computer screen. *Courtesy: Wadsw*

Wadsworth software allows lab technicians to perform initial adjustments to the system in the lab, tailoring it to an individual's needs. Th
system so that a caregiver can simply turn on the computer and click on an icon which brings up two buttons: System Check and Syste
modifications now underway will allow caregivers to readjust the system on an ongoing basis to better serve individual needs.

Outlook for the Future

Wolpaw estimates that about 70-80% of people with severe disabilities could use the current Wadsworth BCI system. Potential users a
ability to learn the system and on the strength of their brain signals. They must be in stable physical condition with some vision, and the
to spend some time familiarizing themselves with the system. Wolpaw's team is currently setting up two new users who have been eval
criteria.

Wolpaw's team hopes to establish a self-sustaining nonprofit organization that would distribute its BCI systems to those who would ben
ensure that those most in need of the system can have access to it," says Wolpaw. The nonprofit group would also provide technical su
system could be widely available within a couple of years says Wolpaw.

"Right now there is a group of people who are completely locked into their bodies and can't communicate with the outside world," says Manasas. "Historically many of these people are known to say 'I don't want to go on and continue.' With this system, there is a shift in people's perception of themselves. They are still part of things."

The Wadsworth Brain-Computer Interface Project has been supported by NIH for the past 14 years. Support from the National Center for Medical Rehabilitation Research (NICHD) began in 1992, and NIBIB has provided primary support for the past 4 years.

New Grant for BCI2000 Team

The Wadsworth BCI system is based on the software system that the lab developed to serve not only as the platform for the Wadsworth BCI in all of its many form but also to serve as a platform that could be used by other BCI researchers. This system is called BCI2000. Whereas other BCI software systems are designed for specific signal and a particular kind of output, BCI2000 is designed so that it can be used with any brain signal, any analysis algorithms, and any of a wide range o output devices. For these reasons, BCI2000 is rapidly becoming the industry standard. The Wadsworth team has made it available for research purposes at no co (see www.bciresearch.org) and maintains a constantly updated website for users. More than 80 labs throughout the world have acquired BCI2000.

To further enhance BCI2000's flexibility, NIBIB recently awarded Gerwin Schalk, chief software engineer of the Wadsworth BCI project, a four-year $1.4 million grant. The grant will enable the Wadsworth team to make BCI2000 more adaptable to users' needs and related technologies and to incorporate into the system support for other hardware, software, and operating systems. In addition, the grant allows the team to develop and maintain documentation and user support so th a larger group of people can benefit from the system.

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Members of the Wadsworth BCI project: (left to right) Scott Hamel, Dean Krusienski, Liz Wolpaw, Dennis McFarland, Dongyan Zhang, Bill Sarnacki, Peter Brunner, Jon Wolpaw, Eric Sellers, Gerv Schalk, Theresa Vaughan, Jan Kubanek
Courtesy: Wadsworth BCI Project