Brainwave Communication Research May Open Doors for the “Locked-in”

by Debbie King (November 2001)

Imagine being able to communicate with others merely by controlling your thoughts. It may sound futuristic, but a research team at the University of Victoria is conducting groundbreaking research in brainwave communication to make this concept a reality for certain types of disabled patients.

The project driving this research involves a seventeen-year old named Claire Minkley. Born with a severe genetic disorder similar to cerebral palsy, Claire has little muscle control. Yet through the tedious process of using a letter board, the straight-A high school student has demonstrated strong intellectual abilities. To achieve her goal to study astronomy and physiology in college, however, Claire will need a more advanced form of communication.

A specialized team of researchers from a variety of disciplines is working to make such communication possible for Claire and other disabled patients who suffer from loss of muscular control. The University of Victoria Assistive Technology Team (UVATT) in Victoria, British Columbia is finding that non-disabled subjects generate periodic brain signals that they can turn on and off.

Bill Hook, communications engineer and project director of the UVATT brainwave communication research, explains that these periodic signals are similar to those generated by the transmitter in a cell phone. According to Hook, the first two non-disabled test subjects generated signals of “incredible purity.” More testing of non-disabled test subjects is planned.

The UVATT hopes this discovery will pave the way for “locked-in” disabled patients such as Claire—-those whose minds are active but who have little or no muscle control--to communicate with others just by flipping a mental switch in their brain.

Funded primarily by a Victoria software development firm, Anthony Macauley Associates, Hook and other UVATT members have spent the last two years developing what is known as coherent detection software, which acts as a receiver for detecting and demodulating the transmitted brain signals. Hook points out that this receiver is similar to those used in cell phones and virtually all digital communications systems.

What distinguishes this software, called the Cyberlink Coherent Detection System, from other brainwave communication devices, is its ability to pick up the periodic brain signals while rejecting "electrical noise" generated by background brainwave activity and involuntary muscle spasms.

The idea for Cyberlink was born from U.S. Air Force technology designed to help pilots perform other tasks while flying using muscle or brain signals. Former Air Force researcher Andrew Junker created the Cyberlink software to provide computer access for the disabled. "It provides a link that lets people who are locked in their body find a way out," says Junker, an electrical engineer and neurophysiologist.

With Junker's permission and help, Hook adapted the Cyberlink software to use coherent detection processing to pick up the periodic brain signals. "We have demonstrated, using a brainwave simulator, that Cyberlink can be reprogrammed using our new software to detect these signals," Hook says.

"Its just like tuning into a radio station and finding a signal," adds Nigel Livingston, biologist and UVATT chair. "You've actually tuned into a particular frequency."

Besides working with Claire, the UVATT is seeking patients suffering from amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig's disease, and brain stem strokes for the next phase of the Cyberlink research: teaching disabled subjects how turn the detected signals on and off. These patients are considered to be ideal candidates because their brains are not affected by the progressive muscle degeneration associated with their disease. Therefore, in theory, they should be able learn to control the periodic brain signals.

Detecting the periodic brain signals in Claire will be more difficult. Livingston points out that, since Claire has no control over her muscles, they fire all the time and generate a lot of electrical noise. “You’ve got to get rid of all of that, and try and tune into this frequency that’s being broadcast,” Livingston explains, “so that’s very technically challenging.” However, Claire’s father, John Minkley, has assured Livingston and Hook that even if she can signal only 15 words an hour, if she can communicate with others without help, it will be an incredible breakthrough.

All test subjects wear a headband or cap of non-invasive electrodes located on the top-back portion of their head and are asked to clear their minds and enter a relaxed mental state. In non-disabled test subjects, the revised Cyberlink software easily detects a large low-frequency brainwave pattern of about 10 Hz (cycles per second). This frequency falls within the range of Alpha waves, typically associated with relaxation or meditation.

Subjects are then asked to visualize a complex mental image, such as a spinning cube. The height, or amplitude, of the brainwave signal, drops sharply to a minimal value. “What you’ve got is two very different states,” says Livingston.

“That’s the start of a communication system,” he continues, “because that’s kind of like yes and no--a binary system.”

By equating the “relaxed” signal with “YES” and a cognitive signal with “NO,” subjects learn to control the brain signals in response to yes/no questions through either auditory or visual feedback.

The signals are amplified, processed, and digitized through a hand-sized piece of hardware, and transmitted to the Cyberlink software on a laptop computer for coherent detection processing. Software packages are available that can interpret the yes/no decisions processed by Cyberlink and translate them into meaningful sentences.

Livingston and Hook envision that patients could be hooked up to a computer that asks the yes/no questions. Once filtered through Cyberlink, the signals could be then fed into the interpretation software, or perhaps eventually a voice synthesizer.

Hook likens their research to the mechanical switch that noted physicist Stephen Hawking uses to communicate. Hawking, who suffers from ALS, operates the switch using hand, head, or eye movement to send messages to a portable computer and speech synthesizer mounted on his wheel chair. "We are trying to replace the switch that Stephen Hawking uses with a brain-wave activated switch," Hook concludes.