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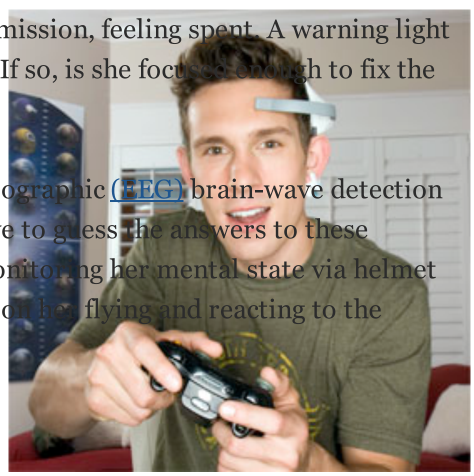
Notion in Motion: Wireless Sensors Monitor Brain Waves on the Fly

Electroencephalography used to require a person to sit still while a computer tracked the brain's electrical impulses. A newer technology untethers this research

By Amber Dance | January 27, 2012 | 1

A fighter pilot heads back to base after a long mission, feeling spent. A warning light flashes on the control panel. Has she noticed? If so, is she focused enough to fix the problem?



"TIP OF THE ICEBERG": NeuroSky, Inc.'s brain-computer interface shown here just scratches the surface of what is possible thanks to advances in mobile electroencephalographic brain-wave detection technology, says University of California, San Diego's Scott Makeig.
Image: Courtesy of Neurosky, Inc.

Thanks to current advances in electroencephalographic (EEG) brain-wave detection technology, military commanders may not have to guess the answers to these questions much longer. They could soon be monitoring her mental state via helmet sensors, looking for signs she is concentrating on her flying and reacting to the warning light.

This is possible because of two key advances made EEG technology wireless and mobile, says Scott Makeig, director of the University of California, San Diego's Swartz Center for Computational Neuroscience (SCCN) in La Jolla, Calif. EEG used to require users to sit motionless, weighted down by heavy wires. Movement interfered with the signals, so that even an eyebrow twitch could garble the brain impulses.

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Modern technology lightened the load and wirelessly linked the sensors and the computers that collect the data. In addition, Makeig and others developed better algorithms—in particular, independent component analysis. By reading signals from several electrodes, they can infer where, within the skull, a particular impulse originated. This is akin to listening to a single speaker's voice in a crowded room. In so doing, they are also able to filter out movements—not just eyebrow twitches, but also the muscle flexing needed to walk, talk or fly a plane.

EEG's most public face may be two Star Wars–inspired toys, Mattel's Mindflex and Uncle Milton's Force Trainer. Introduced in 2009, they let wannabe Jedi knights practice telekinesis while wearing an EEG headset. But these toys are just the "tip of the iceberg," says Makeig, whose work includes mental concentration monitoring. "Did you push the red button and then say, 'Oops!' to yourself? It would be useful in many situations—including military—for the system to be aware of that."

That kind of "mental gas gauge" is just one of many projects Makeig is running at the SCCN, which is part of U.C. San Diego's Institute for Neural Computation (INC). He also combines mobile EEG with motion-capture technology, suiting volunteers in EEG caps and LED-speckled spandex suits so he can follow their movements with cameras in a converted basement classroom. For the first time, researchers like Makeig can examine the thoughts that lead to movement, in both healthy people and participants with conditions such as autism. Makeig calls the system Mobile Brain/Body Imaging, or MoBI. It allows him to study actions "at the speed of thought itself," he says.

EEG does not directly read thoughts. Instead, it picks up on the electrical fields generated by nerves, which communicate via electricity. The EEG sensors—from the one on the *Star Wars* games to the 256 in Makeig's MoBI—are like microphones listening to those microvolt-strength neural signals, says Tansy Brook, head of communications for NeuroSky Brain–Computer Interface Technology in San Jose, Calif., makers of the chip in the *Star Wars* toys and many other research, educational and entertainment products.

For one project, Makeig is collaborating with neuroscientists Marissa Westerfield and Jeanne Townsend*, U.C. San Diego researchers studying movement behavior in teenagers with autism. They put the teens, wearing the EEG sensors and LEDs, in Makeig's special classroom. Then, they project a spaceship on the walls. The kids have to chase the spaceship as it darts from one point to another. Although the results are not yet in, Westerfield suspects that people with autism, compared with those who are non-autistic, will take longer to process where the spaceship has gone and readjust their movements toward it. "If we had a better idea of the underlying deficits...then we could possibly design better interventions," such as targeted physical therapy for the movement problems autistic people have, Westerfield says.

Neuroscientists and psychologists have been using EEG to eavesdrop on brain waves since 1926, and doctors employ it to study sleep patterns and observe epileptic seizures. During most of that time, subjects had to sit in an electrically shielded booth, "like a big refrigerator," says John Foxe, a neuroscientist at Albert Einstein College of Medicine in New York City. He calls Makeig's MoBI "technical wizardry" that will enable scientists "to watch the brain and how it works in much more realistic settings."

Wireless EEG has already had an impact on gaming. San Francisco–based Emotiv has since 2009 sold its EPOC EEG headset, which uses electrical signals to determine a player's emotional state—excitement, frustration and boredom each create a different pattern. Gamers using Emotiv's technology can also create mental "spells" to lift or push virtual objects, says Geoff Mackellar, CEO of Emotiv's research unit based in Sydney, Australia. The EPOC is also regularly used in research labs and may have medical applications in the future, Mackellar adds.

Wireless EEG technology provides signals as clear as the wired version, Makeig says, and at about 3.5 kilograms his machinery is "luggable." (Emotiv's and NeuroSky's headsets, which use fewer electrodes, are lighter.) "Of course, we're not starting with ballet dancers doing *The Rite of Spring*," he admits, but the team has succeeded with joggers on a treadmill. One challenge they would still like to overcome is to remove the sticky, conductive gel that goes under each electrode. It can certainly be done—Emotiv's electrodes use only saltwater and NeuroSky's are dry.

Tzyy-Ping Jung, associate director of the SCCN, predicts the group will make a dry, 64-electrode system within a couple of years. He and Makeig envision the headset will help paralyzed people interact with the world, warn migraine sufferers of an impending headache, and adjust computerized learning to match a student's personal pace, among other potential applications.

"It's certainly something that everyone can have at home," Emotiv's Mackellar says.

**Correction (1/27/12): This sentence was edited after posting. It originally referred to Jeanne Townsend as Jean Thompson.*

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