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Schmidek and Sweet: Operative Neurosurgical Techniques: Indications, Methods ...

By Alfredo Quinones-Hinojosa

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membrane to alter the cell resting potential. The ion pumps are light-sensitive, so they pump chloride ions into cells when activated by yellow-green light. Lowering voltage inside the cells silences their firing.[108] Using optics to systematically drive or inhibit an array of distinct circuit elements in freely moving parkinsonian rodents, Gradinaru and colleagues[109] found therapeutic effects within the subthalamic nucleus by direct selective stimulation of afferent axons projecting to this region. The results demonstrate an optical approach for controlling disease circuitry by selectively controlling individual components. Preclinical testing of this approach has started in non-human primates, to assess its safety as a potential therapy for Parkinson's disease, epilepsy, and chronic pain.

As with all advances in technology, the U.S. military has been exploring applications for BCIs to enhance troop performance as well as to develop systems for silent communication. Since 2000, the Pentagon has funded efforts to build prototype cockpits, missile control stations and infantry trainers that can sense the operator's focus of attention, and adjust how they present information to find targets easier by tapping their unconscious reactions.[110] The *Silent Talk* program[111] aims to "allow user-to-user communication on the battlefield without the use of vocalized speech through analysis of neural signals." Before being vocalized, speech exists as word-specific neural signals in the mind. The research aims to detect and analyze the word-specific "pre-speech" neural signals (EEG), which occur before speech is vocalized. After identifying the patterns, they could then transmit the statement to another soldier. They are also testing in a project to devise mind-reading binoculars. The "soldier-portable visual threat warning devices" would include a software system to monitor brain activity and quickly alert soldiers to potential threats (the idea being that EEG can recognize "neural signatures" for target detection before the conscious mind becomes aware of a potential threat or target).

These types of approaches will intensify the ethical debate as BCIs become more technologically advanced and it becomes apparent that they may not just be used therapeutically but also for human enhancement. Today's brain pacemakers, which are already used to treat neurologic conditions such as depression, could become a BCI to modify other behaviors. Some praise brain implants as part of a next step for humans in progress, whereas others view them as corrupting humanity into losing essential human qualities. It raises people's fear that implants may be used for mind control. These include designing a fully implantable biocompatible recording device, further developing real-time computational algorithms, introducing a method for providing the brain with sensory feedback from the actuators, and designing and building artificial prostheses that can be controlled directly by brain–derived signals.

Conclusion

Multiple functional BCIs have demonstrated the proof of principle using different electrodes and recording techniques. Nevertheless, there is considerable work required to bring this technology to a practical state. Currently, far too much energy is required to maintain the system and nothing yet even approaches stand-alone technology. There is a need to improve all aspects of the technology. This is not the time to standardize or obstruct the development of any technology. The ultimate design may well be a hybridized combination of technologies and may include repair and regenerative therapeutics of neural transplantation and gene transfer. More innovative approaches are required and in this a neurosurgeon can play a significant role in helping the bioengineers understand the limitations and possibilities of surgical manipulation of the brain. Likewise, intimate knowledge of bioengineering certainly will help neurosurgeons understand where they can be supportive in improving the procedure.

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