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Technology Corner – Brain Computer Interface with Dr. Daniel Kramer [1]

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Imagine a small device implanted in the brain of someone paralyzed by a spinal cord injury that allows them to control the movements of robotic legs. Or maybe the implanted device helps improve short-term memory in patients with age-related dementia. These scenarios could be made possible through the technology of brain-computer interfaces (BCIs). In short, BCIs acquire brain signals, analyze them, and translate them into commands that are relayed to output devices that conduct desired actions. The goal of BCI is to replace or restore useful function to people disabled by neuromuscular disorders such as ALS, cerebral palsy, stroke, or spinal cord injury. They may also prove useful for rehabilitation after strokes and for other disorders. Researchers have successfully learned how to use BCIs for increasingly complex control of cursors, robotic arms, prostheses, wheelchairs, and other devices. In the future, BCIs might help the performance of surgeons or other medical professionals.

Dr. Daniel Kramer, a neurosurgeon and assistant professor of neurology at the University of Colorado Anschutz Medical Campus, is leading a BCI research team at UCHealth University of Colorado Hospital. Dr. Kramer's specialty is functional neurosurgery to restore function to patients with chronic neurological disorders. His BCI team is part of a national effort to restore motor and sensory function to patients with debilitating diseases and eventually help patients with memory and cognitive issues. As Dr. Kramer explains, "Brain computer interface is the moon landing of the neuroscience world."

One of the challenges of BCIs is learning how neurons control motor function. To overcome this, Dr. Kramer and his team collect data directly from the brain during the deep brain stimulation surgeries he regularly preforms on patients with Parkinson's or epilepsy to reduce tremors. With a patient's permission, he implants electrodes into the patient's brain and connects them to specialized computer equipment and sensors. Then, he asks the patient to do a series of finger pointing movements, collecting data about the neural activity, and uploading it to a computer program. The recording and testing process takes three minutes, and, afterwards, Kramer resumes the deep brain stimulation surgery.

Kramer's team uses the data collected during surgeries to decode signals sent along neural pathways, mapping and recording the electrical signals that control a particular movement. They can then leverage this data to help optimize computer programs used during a BCI implantation procedure that will allow a patient's brain to tell a device, such as a robotic arm, what action the patient wants to perform. His team is also using this data to better understand the complex circuitry that enables smooth and precise movements.

Dr. Kramer's research happens at the junction of neuroscience and neural engineering. His specialty is called functional neurosurgery because that is exactly what he is doing – restoring

function. His procedures are remarkable and life changing. For example, ALS patients who have lost their ability to speak due to muscle weakness can communicate again by writing messages using their brain signals. Likewise, a paralyzed patient was able to use a robotic arm to pick up a can of beer, bring it to his mouth, and take a drink.

Dr. Cathy Bodine, the Coleman Institute's Executive Director, explains the significance of BCIs – "It's the new frontier in medicine. When we combine things like machine learning, artificial intelligence, and brain computer interface, we're already seeing how this can improve the quality of life and health for people who have disorders like Parkinson's.

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