ReHAB

Reconnecting the Hand and Arm to the Brain

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Three Cleveland organizations receive $3 million Department of Defense grant to test new brain-arm-hand interface for severely paralyzed patients

University Hospitals Cleveland Medical Center, Case Western Reserve University and Cleveland Functional Electrical Stimulation Center to test sophisticated system letting thoughts move immobile arm in natural ways

CLEVELAND—Six years ago, a team of researchers from University Hospitals Cleveland Medical Center and Case Western Reserve University, in collaboration with the Braingate2 consortium, developed a system of muscle stimulation controlled by a brain-computer interface that allowed a paralyzed person to move his previously immobile arm.

Now, the same group of biomedical pioneers is poised to take the next step, advancing a platform to allow unprecedented reanimation of paralyzed limbs under direct control of the brain.

The upgraded system, called ReHAB (for "Reconnecting the Hand and Arm to the Brain"), uses an extensive array of sensors surgically implanted into different brain areas along with high-density stimulating electrodes placed directly on hand, arm, and shoulder nerves. The researchers believe the new system will give paralyzed people the ability to do more than ever before. They will soon be starting a new clinical trial to evaluate its safety and effectiveness.

"With ReHAB, we will be implanting a sophisticated system that will let the brain move the arm in natural ways using thought alone, something that has never been done before," said

Jonathan Miller, MD, Professor of Neurosurgery at UH and Case Western Reserve School of Medicine.

Dr. Miller is joined by co-principal investigators Bolu Ajiboye, PhD, Associate Professor of Biomedical Engineering at the Case School of Engineering, and Robert Kirsch, PhD, Professor and Chair of Biomedical Engineering at Case Western Reserve and Executive Director of the Cleveland Functional Electrical Stimulation (FES) Center.

Funded by a $3 million grant from the United States Department of Defense and supported by U.S. Food and Drug Administration approval, the new system has the potential to offer better function than any previous brain-computer interface or functional electrical stimulation projects. The system also may offer participants a chance to regain sensation in the hand.

But there could be more: Ajiboye said researchers hope to restore to clinical trial participants something called “proprioception”—the ability to know where your limb is even with your eyes closed.

“We aim to restore different sensory perceptions, including touch and proprioception, to persons with paralysis by applying electrical micro-stimulation directly to the brain,” Ajiboye said. “Not only will doing so likely enhance the restored motor function, but we believe the level of ownership felt by participants will also be significantly increased. Direct sensory feedback will enhance the feeling that ‘This is mine, my arm. This is me.’”

Also involved with the research are Jennifer Sweet, MD, UH neurosurgeon, and Anand Kumar, MD, UH Chief of Plastic and Reconstructive Surgery.

Kirsch said the leap from BrainGate to ReHAB is on two fronts—the brain interface and the functional electrical stimulation (FES)—but that in both cases it has required a committed collaboration.

“This is not just a demo this time, but a way to give real function to these folks,” he said. “But these kind of projects really are what I would call big, team science, and it takes all of us to make this happen.”

How ReHAB would work

ReHAB has several new and different features compared with other systems, according to Dr. Miller.

“ReHAB is different from previous work in the area in several ways,” said Dr. Miller. “For the first time, we will be simultaneously looking at several different brain areas involved in movement planning. In addition, we are using new peripheral nerve electrodes that were initially designed by Dustin Tyler, PhD (the Kent H. Smith Professor of Biomedical Engineering, Case Western Reserve University, and Associate Director, Cleveland Advanced Platform Technology), to provide stimulation to sensory nerves so that amputees could better use prosthetic arms.

“These electrodes spread the nerve and use many small contacts that are able to stimulate nerve fibers selectively. These electrodes have the potential to provide even more precise control of movement than we were able to accomplish in our previous studies.”

The nerve electrodes will be controlled by signals recorded from several small electric arrays, each about the size of a baby aspirin tablet, implanted into the surface of the participant’s brain to record neural activity related to intended movements. In other words, the brain arrays read the participant’s electrical signals and translate them into command signals used by the peripheral electrodes to control movements of the arms, hands, and fingers.

“Each brain array will have a few-dozen channels and will allow recording from the brain and also stimulation to simulate sensation for feedback,” Dr. Miller said. “The idea is that the patient will not only be able to move his or her hands, but will also be able to tell what the hand is doing, by feeling sensations in the hand and fingers and perceiving where the hand is located.

“If this works, it could be a huge step forward to allow paralyzed people to interact with their environment again and regain function lost as a result of disease or injury.”

Dr. Miller and team hope to implant the brain arrays in early 2020.

The brain array is connected by wire through the skull to amplifiers at the top of the head. The amplifiers will be plugged into the arm stimulator to stimulate the muscles. Success with this project may eventually have implications for controlling movement in other areas of the body, including the legs and trunk.

Cleveland has a long history in FES, with work in upper arm, leg, and trunk stimulation.

More information about ReHAB can be found:
https://www.clinicaltrials.gov/ct2/show/NCT03898804

About University Hospitals / Cleveland, Ohio

Founded in 1866, University Hospitals serves the needs of patients through an integrated network of 18 hospitals, more than 50 health centers and outpatient facilities, and 200 physician offices in 16 counties throughout northern Ohio. The system’s flagship academic medical center, University Hospitals Cleveland Medical Center, located in Cleveland’s University Circle, is affiliated with Case Western Reserve University School of Medicine. The main campus also includes University Hospitals Rainbow Babies & Children's Hospital, ranked among the top children’s hospitals in the nation; University Hospitals MacDonald Women's Hospital, Ohio's only hospital for women; University Hospitals Harrington Heart & Vascular Institute, a high-volume national referral center for complex cardiovascular procedures; and University Hospitals Seidman Cancer Center, part of the NCI-designated Case Comprehensive Cancer Center. UH is home to some of the most prestigious clinical and research programs in the nation, including cancer, pediatrics, women's health, orthopedics, radiology, neuroscience, cardiology and cardiovascular surgery, digestive health, transplantation and urology. UH Cleveland Medical Center is perennially among the highest performers in national ranking surveys, including “America’s Best Hospitals” from U.S. News & World Report. UH is also home to Harrington Discovery Institute at University Hospitals – part of The Harrington Project for Discovery & Development. UH is one of the largest employers in Northeast Ohio with 28,000 physicians and employees. **Advancing the Science of Health and the Art of Compassion** is UH’s vision for benefitting its patients into the future, and the organization’s unwavering mission is To Heal. To Teach. To Discover. Follow UH on LinkedIn, Facebook @UniversityHospitals and Twitter @UHhospitals. For more information, visit UHhospitals.org.

About Case Western Reserve University

Case Western Reserve University is one of the country's leading private research institutions. Located in Cleveland, we offer a unique combination of forward-thinking educational opportunities in an inspiring cultural setting. Our leading-edge faculty engage in teaching and research in a collaborative, hands-on environment. Our nationally recognized programs include arts and sciences, dental medicine, engineering, law, management, medicine, nursing and social work. About 5,100 undergraduate and 6,200 graduate students comprise our student body. Visit case.edu to see how Case Western Reserve thinks beyond the possible.

About Cleveland Functional Electrical Stimulation (FES) Center

The Cleveland FES Center is a neuromodulation and neurostimulation research consortium of five nationally recognized institutions: Louis Stokes Cleveland VA Medical Center, MetroHealth Medical

Center, Case Western Reserve University, University Hospitals of Cleveland, and the Cleveland Clinic Neurological Institute. The Cleveland FES Center is at the forefront of academic and clinical research to further the advancement of neural technology; thereby accelerating the translation of innovation into clinical practice and improving the quality of life for people with neural disorders and their families. FEScenter.org