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Alleviating paralysis with new brain-reading technologies

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People with locked-in syndrome can communicate only with their eyes. Credit: CC0 via Unsplash

EU-backed scientists are making progress in efforts to give people with impaired motor functions more independence.

In 2009, a former U.S. policeman named Richard Marsh suffered a severe stroke that left him completely paralyzed but conscious—a condition known as locked-in syndrome.

Little more than four months later, in a miracle of sorts, Marsh recovered to the point of being able to walk out of his intensive-care facility.

Communication breakdown

Most people with locked-in syndrome, a rare neurological disorder, have no such good fortune. While being conscious, patients usually remain almost completely paralyzed and unable to communicate.

A new research project could offer them some hope. Called INTRECOM, the project has received EU funding to enable people with locked-in syndrome to communicate through an implantable brain-computer interface.

"The device is basically ready, but there's extensive tests that need to be done to make sure it's safe for permanent implantation," said Professor Nick Ramsey, a neuroscientist at the University Medical Center of Utrecht in the Netherlands. "That's what we are doing now."

Ramsey coordinates INTRECOM, which began in December 2022 and runs for four years.

A handful of confirmed cases of locked-in syndrome occur worldwide every year. It is caused by brainstem damage resulting from a stroke or neuromuscular disease such as amyotrophic lateral sclerosis, or ALS.

"The brain still does everything it is supposed to do but the signals it sends to the body don't arrive," Ramsey said.

Hard-wired

The device has three parts: 128 electrodes placed in the brain, electronics that amplify the signals collected and a device that packages the information and wirelessly transmits it to a computer.

All this hardware had to be miniaturized so it can be implanted.

Otherwise, wires would have to go through the patient's skin and would create a risk of infection "like a highway for bacteria into the brain," said Ramsey.

Once safety tests have been conducted, the plan is to implant the device in two patients with ALS. One of them is in Utrecht and the other in the Austrian city of Graz.

The INTRECOM researchers aim to carry out the implantations in 2024 or early 2025.

Speech decoding

The team will then turn its sights to software: testing an artificial-intelligence algorithm for decoding the brain signals.

The software research will be challenging because, as there are no patients with 128 implanted electrodes, the information needed to create the decoding models is unavailable.

"We will have to conduct a lot of data collecting experiments to get the data that we need to start decoding speech," said Ramsey. "One of the ways we will do that is by having the patient read in their mind 'aloud'—because of course they can't speak—from texts that we offer."

The researchers can then start labeling brain data for the software as they will know exactly what the patient is trying to say.

The team will train the system first to understand a handful of commands from the patients so that they can select letters and spell out words on screen.

The hope is that the patients will begin communicating with their families within months of having the implants fitted.

The ultimate aim is to let patients communicate in a more natural way via a voice synthesizer. The researchers anticipate that patients will be able to start doing this after about a year.

Ramsey and his team intend after INTRECOM ends in November 2026 to pursue a new project to implant the brain-computer interface in 10 more people.

Spinal-injury focus

Brain implants can decode more than speech signals and are used in patients who suffer loss of motor function as a result of a spinal-cord injury, which afflicts around 750,000 people a year.

In these patients, the implant is part of a system that bypasses the spinal injury to reconnect neural activity to their limbs so that they can be used again.

An EU-funded project called NEMO BMI is trying to make life easier for them.

After their brain-machine interface is initially set up, such patients have periodically to return to the laboratory and have the system recalibrated.

They sit with an assistant to adjust the model that decodes their brain activity until their limbs are doing what they want.

NEMO BMI, which runs for three years through September 2025, would do away with this step by making the periodic recalibrations happen automatically whenever needed. The project would also embed brain-signal decoding in a silicon chip for autonomous use at home.

"It might be that, one day, we move from supervised recalibrations of the decoding model to autonomous updates," said Dr. Tetiana Aksenova, the project coordinator and a neural engineer at research institute CEA Grenoble in France.

Digital bridge

NEMO BMI is the continuation of work initiated under a clinical trial to restore mobility in people with spinal-cord injury using brain-machine interfaces.

In May 2023, a research team involved in this trial reported having enabled a tetraplegic man from the Netherlands to stand and walk again.

The team did so by restoring communication between his brain and spinal cord, which had been damaged in a traffic accident in 2011.

The scientists used a "digital bridge" that linked neural activity detected by a brain implant to electrodes that stimulated the nerves in the man's spine.

When the patient tries to move his legs, his muscles now respond in the way he intends.

Action and intent

For their part, the NEMO BMI researchers are seeking to detect a possible signal that shows 'if the action corresponds to the patient's intent," said Aksenova.

Using such brain signaling, their system would determine whether patients are satisfied with their motor control and, if not, recalibrate the device that decodes the signal as needed.

The NEMO BMI team is working with three patients. In preliminary study, a satisfactory signal was identified in one of them.

"Now we try to generalize this approach to our three patients in different scenarios," Aksenova said.

With NEMO BMI only a third of the way through and plenty of questions still unanswered, she's cautiously optimistic of more progress over the remaining two years of the project.

More information:

- INTRECOM
- NEMO BMI

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