Medical Xpress

Thinking makes it so: Science extends reach of prosthetic arms

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Motorized prosthetic arms can help amputees regain some function, but these devices take time to learn to use and are limited in the number of movements they provide.

Todd A. Kuiken, M.D., Ph.D., a physiatrist at the Rehabilitation Institute of Chicago and professor at Northwestern University, has pioneered a technique known as targeted muscle reinnervation (TMR), which allows a prosthetic arm to respond directly to the brain's signals, making it much easier to use than traditional motorized prosthetics. This technique, still under development, allows wearers to open and close their artificial hands and bend and straighten their artificial elbows nearly as naturally as their own arms.

"The idea is that when you lose your arm, you lose the motors, the muscles and the structural elements of the bones," Kuiken explained. "But the control information should still be there in the residual nerves." He decided to take the residual nerves, which once carried the commands from the brain to produce arm, wrist and hand movements, and connect them to the chest muscles so that the signals can be used to move the artificial limb.

Nearly a dozen patients who have undergone TMR so far have motorized prosthetic arms that produce two arm movements: open and close hand and bend and straighten elbow. But in a new study from the Journal of Neurophysiology, published by The American Physiological Society, Kuiken and his colleagues demonstrate that TMR has the potential to provide an even greater number of arm and hand movements, beyond the four they've already achieved. The researchers have begun work with two U.S. Army medical centers to help soldiers who have lost limbs.

The study, entitled "Decoding a new neural-machine interface for control of artificial limbs," was conducted by Ping Zhou, Madeleine M. Lowery, Kevin B. Englehart, He Huang, Guanglin Li, Levi Hargrove, Julius P.A. Dewald and Kuiken, all of Northwestern University and the Rehabilitation Institute of Chicago. Hargrove is also affiliated with the University of New Brunswick, Canada and Lowery is also affiliated with University College Dublin, Ireland.

Redirects nerves

Kuiken first got the idea for TMR when he was a graduate student during the 1980s. In his first patient, Kuiken took four nerves that had gone to the amputated arm and redirected them to the patient's chest muscles. As a result, when the patient wants to close his hand – a hand that is no longer there – the impulse travels down the nerve, into his chest and causes the chest muscle to contract.

The next step was to use the muscle contraction in the chest to move the prosthetic arm. This was accomplished with the help of an electromyogram (EMG), which picks up the electrical signal that the muscle emits when it contracts.

The signal is directed to a microprocessor in the artificial arm which decodes the signal and tells the arm what to do. In their work thus far, Kuiken and his colleagues have programmed the processor in the prosthetic arm to recognize four signals to produce two arm movements: open and close hand and bend and straighten elbow.

The result" When the patient thinks 'close hand' the hand closes.

Contrast this with current motorized prosthetic arm technology: The patient has to learn to use new muscle groups to move the prosthetic arm; can perform only one movement at a time; and must contract two muscles at once to achieve a new movement.

"It's not very common to flex your chest muscle to close your hand or bend your wrist," said Kuiken. "Quite frankly, most people with a unilateral shoulder disarticulation amputation don't wear a prosthesis at all: It's just too cumbersome."

More moves

While TMR is more intuitive and natural, Kuiken and his team wanted to see if they could extract more of the wealth of information from the electrical signals produced by the nerves and chest muscles and harness it to provide a greater number of hand and arm movements.

In the study published in the Journal of Neurophysiology, they placed between 79-128 electrodes from the EMG onto the chest muscles of five patients to see if they could identify the unique EMG patterns emitted with 16 different elbow, wrist, hand, thumb and finger movements they asked the patients to perform. The EMG signals from each of the 16 movements were analyzed using advanced signal processing techniques. The study found that the researchers could recognize the signals associated with the different arm movements with 95% accuracy.

The next step is to use this information to program these new moves into the microprocessor of the artificial arm, so that instead of just opening and closing a hand and bending and straightening an elbow, now the signals can produce various hand grasp patterns, such as the one needed to hold a baseball, pick up a pen or grasp a tool.

May benefit soldiers

Kuiken and his colleagues have begun to work with the military at Brooke Army Medical Center at Fort Sam Houston in Texas and the Walter Reed Army Hospital in Washington, D.C. to apply this technology to soldiers who have lost limbs.

“We’re excited to move forward in doing this surgery with our soldiers some day,” he said. “We’ve been able to demonstrate remarkable control of artificial limbs and it’s an exciting neural machine interface that provides a lot of hope.”

There are a couple of additional things to note in the work of Kuiken and his colleagues: They performed nerve transfer surgery 9-15 months after the injury that led to amputation, showing that these neural pathways remain intact, even when they have not been used for awhile.

Also, when the researchers touch these patients on their chests, the patients say it feels like they are being touched somewhere on their arm or hand -- the arm or hand that is no longer there. That’s not really surprising, because the brain receives an impulse from a nerve that used to go to the arm. The brain doesn’t know the nerve is now embedded in a different muscle, and interprets this touch as it always has.

Source: American Physiological Society