New prosthetic invention lets users reclaim their sense of touch

24 March 2017, by Michelle V. Moncrieffe

Two years ago, Melissa Loomis, age 43, was in her house in Ohio when she heard her two dogs barking and scuffling outside. She discovered her pets in a tussle with a raccoon and ran to intercede. The wild animal bit her right forearm. Twenty-nine days and 13 surgeries later, Loomis lost her limb above the elbow to a septic infection. Suddenly, everyday activities such as brushing her teeth, buttoning a blouse, or lifting a pot while making dinner became a challenge. At the suggestion of her surgeon, Loomis came to the Johns Hopkins Applied Physics Laboratory to test a breakthrough in prosthetics. Today she is one of the world's first amputees to regain a sense of touch through a mind-controlled prosthetic robotic arm.

The design of this next generation modular prosthetic limb has been years in the making by engineers at APL, through a program funded by the U.S. Defense Advanced Research Projects Agency, known as DARPA. With 26 joints, the prosthesis can curl up to 45 pounds and matches the natural dexterity of a human arm. Coming in at just over 9 pounds, it weighs little more than a human arm, and it's designed to integrate with the body and use the brain's natural neurotransmissions for control. It represents a major leap forward in prosthetics, as amputees often contend with heavy, uncomfortable, and static replacements, says Mike McLoughlin, chief engineer of the Research and Exploratory Development Department at APL. "There were two challenges: to emulate the human arm and provide the control that is very natural," he says.

This iteration is the first to provide sensory feedback to the amputee.

Loomis first underwent a 16-hour surgery called targeted sensory reinnervation. Several nerves send signals from the brain down to the hand, but when the limb is missing, those messages have nowhere to go (accounting for the phantom limb sensation many amputees experience). By surgically grafting those nerves onto a new location of the remaining upper arm, and then connecting those nerves to a sensory cap that attaches the arm to the prosthesis, it stimulates the nerves that used to go to the hand.

Only instead of controlling a physical hand, the amputee is controlling the prosthesis. The simulation cap works by transmitting electric signals directly from the nerves to the prosthesis, thus reactivating those paths to the brain. Think Grab the ball, and the hand will grab the ball. "The power in this is that we don't have to trick the brain; we use what was already there," McLoughlin says, "so the brain doesn't have to learn how to interpret signals from the prosthesis."

In early tests in April 2016, Loomis strapped the simulation cap onto her arm with the remapped nerves, and using her mind to control the prosthesis, she picked up and dunked an orange ball in a basket. More important, though, she could feel the ball in the mechanical hand. Over 100 sensors in the arm sent messages back to her brain.

"You control your hand with your mind naturally, so to me I feel like I have a hand and I'm moving it naturally," Loomis told Motherboard magazine on the day of the trial at APL. "It's just incredible. I felt the orange ball."

McLoughlin says that this development brings hope to people who have lost limbs through stroke, illness, and accidents, as well as to those born without complete limbs. It's a "conduit to mobility," he says, and would allow people not only to have the function of the arm but to feel the hand of a spouse, or the warning warmth of a hot surface. "If you would have told me this when I was a boy, I would not have believed it," McLoughlin says. Researchers aim to make the next phase of this program noninvasive: imagine no surgeries or implants—just placement of a sensory cap. To make this technology accessible to patients like Loomis, his team is working now to drive down the cost.

Provided by Johns Hopkins University