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Pioneering brain implant restores paralysed man's sense of touch

More-advanced implants will be needed to restore full sensation throughout the body.

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University of Pittsburgh researcher Andrew Schwartz shakes the robotic hand controlled by Nathan Copeland

For the first time, a paralysed man has gained a limited sense of touch, thanks to an electric implant that stimulates his brain and allows him to feel pressure-like sensations in the fingers of a robotic arm.

The advance raises the possibility of restoring limited sensation to various areas of the body, as well as giving people with spinal-cord injuries better control over prosthetic limbs. But restoring human-like feeling, such as sensations of heat or pain, will prove more challenging, the researchers say.

Nathan Copeland had not been able to feel or move his legs and lower arms since a car accident snapped his neck and injured his spinal cord when he was 18. Now, some 12 years later, he can feel when a robotic arm has its fingers touched, because sensors on the fingers are linked to an implant in his brain.

Brain implant restores paralysed man's sense of touch
Rob Gaunt, a biomedical engineer at the University of Pittsburgh, performs a sensory test on a blindfolded Nathan Copeland. Nathan, who is paralysed, demonstrates his ability to feel by correctly identifying different fingers through a mind-controlled robotic arm. Video credit: UPMC/Pitt Health Sciences.

“He says the sensations feel like they’re coming from his own hand,” says Robert Gaunt, a biomedical engineer at the University of Pittsburgh who led the study.

“I can feel just about every finger—it’s a really weird sensation,” Copeland said, about a month after surgery, in a press release. “Sometimes it feels electrical and sometimes its pressure, but for the most part, I can tell most of the fingers with definite precision. It feels like my fingers are getting touched or pushed.”

Dustin Tyler, a biomedical engineer at Case Western Reserve University in Cleveland, Ohio, says the results as “a significant and critical advance” and a step towards restoring sensation in people with paralysis.

The project's funders, the Defense Advanced Research Projects Agency, had revealed the advance in September 2015, but full details of the work were published on 13 October in *Science Translational Medicine*[1].

Augmented limbs
The work builds on previous achievements, whereby prosthetic arms fitted with touch sensors and wired into nerves in the stumps left by amputation allowed participants to perceive pressure and texture. But achieving the feat in people with spinal-cord injuries is more challenging because the connections between their limbs and brain have been damaged or severed.

Electrically stimulating the brain region that received sensory information from the rest of the body, the somatosensory cortex, can produce touch-like sensations, according to experiments in people undergoing brain surgery for other reasons. But these were relatively crude efforts. “People have described feeling a buzz or a vibrating sensation, but it isn’t a natural thing and it usually crosses multiple fingers,” says Elizabeth Tyler-Kabara, a neurological surgeon at the University of Pittsburgh in Pennsylvania and a co-author of the current study.

Copeland, by contrast, had two microelectrode arrays (each about 4 millimetres across) implanted into his somatosensory cortex, and two other electrodes positioned in the portion of the motor cortex that controls hand and arm movement. Wires from all of these electrodes passed out of his head, and could be connected to a computer and a robotic arm.

When the team stimulated the sensory brain areas four weeks after implanting the device, Copeland experienced touch-like sensations when the electrodes were activated by the computer. And when sensors on the fingers of the robotic arm linked to electrodes in Copeland’s brain were touched, he could tell which fingers were being stimulated — and sometimes, which regions of those fingers.

The paper describes the first 6 months of the experience, but Copeland has now had the implant for 17 months and the responses have remained stable. This is encouraging, says Tyler-Kabara, because it suggests that the connections do not alter with time and that the electrical stimulation is not damaging the brain.

There are limitations. Although Copeland reported feeling basic pressure-like touch, he did not experience sensations of movement, temperature or pain; nor can he feel the fingertips or thumb of the robotic arm. Moving the chips or adding more of them might render more of the hand sensitive. However, feelings such as movement are perceived by less accessible brain regions than are sensations of pressure — and the brain regions corresponding to some other body parts such as the feet are also less accessible than those for the hands.

Deep implants

These challenges could potentially be overcome by developing refined implants with more electrodes, or using flexible materials that can be implanted deeper into the brain. Researchers are also looking into wireless connections between implants and prostheses. With current technology, every extra chip needs more wires connected to the brain, which increases the risk of infection.

Even with these advances, it is still unlikely that full sensation could be imbued to a robotic arm, says Andrew Jackson, a neuroscientist at Newcastle University, UK. “The kind of dextrous manipulation that able-bodied people take for granted relies upon a very complex signal from many receptors in your hand, so I think these techniques are likely to be of limited use in terms of improving control.”

Still, reinstating even a basic sense of touch to those with paralysed or missing limbs could transform their lives, Jackson adds. “If someone hasn’t felt their arm for many years, it could make an awful lot of difference in terms of how they feel about their connection to the outside world.”

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References

1. Flesher, S. N. *et al*. *Sci. Transl. Med.* **8**, 361ra141 (2016).