Prosthetic hands with a sense of touch? Breakthroughs in providing 'sensory feedback' from artificial limbs

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Researchers are exploring new approaches to designing prosthetic hands capable of providing "sensory feedback." Advances toward developing prostheses with a sense of touch are presented in a special topic article in the June issue of *Plastic and Reconstructive Surgery*, the official medical journal of the American Society of Plastic Surgeons (ASPS).

Emerging sensory feedback techniques will provide some sensation and enable more natural, intuitive use of hand prostheses, according to the review by ASPS Member Surgeon Paul S. Cederna, MD, of University of Michigan, Ann Arbor, and colleagues. They write, "These breakthroughs pave the way to the development of a prosthetic limb with the ability to feel."

'Nerve Interfaces' May Allow Feeling in Prosthetic Hands

Upper limb loss is a "particularly devastating" form of amputation, since "a person's hands are their tools for everyday function, expressive communication, and other uniquely human attributes," according to Dr. Cederna and coauthors. The functional, psychological, economic, and social impact is even greater since most upper limb amputations occur in young, otherwise healthy individuals.

Current robotic prostheses approach the fine dexterity provided by the human hand—but these advances have outpaced developments in providing sensory feedback from artificial limb. "The lack of sensation...is the key limitation to reestablishing the full functionality of the natural limb," Dr. Cederna and colleagues write.

Providing some sense of touch to the artificial hand would lessen the "cognitive burden" of relying solely on vision to initiate and monitor movements—while also providing "tremendous psychological benefits" for patients. The review focuses on recent and emerging technologies to create "sensory interfaces" with the peripheral nerves to provide feeling to prostheses.

Already in use is a technique called *sensory substitution*, in which one type of sensation is substituted for another. For example, vibration applied to skin on the remaining limb, or to another part of the body, is used to convey touch from sensors on the prosthesis.

Other techniques use various types of implanted neural interfaces—electrodes placed in or around the nerves—which are stimulated by sensors on the prosthesis. These *direct neural stimulation* approaches show promise in enabling patients to feel object characteristics such as stiffness, shape, and size, or to control fine-motor movements without visual cues.

A promising newer technique is *targeted muscle reinnervation* (TMR), in which nerves are transferred to provide sensation to intact muscles and overlying skin. Originally developed to improve control of the prosthesis, TMR approaches are being studied to elicit sensory feedback from the prostheses.

Experimental approaches seek to avoid the need for nerve electrodes. The authors' lab is working on a technique called the *sensory regenerative peripheral nerve interface* (sRPNI), in which a "bioartificial interface" transfers sensory signals directly from a prosthetic sensor to the remaining nerve.

Another "next generation" approach is the use of *optogenetic* technology to control nerve signaling using specific light wavelengths. Although studied only in animals so far, optogenetics offers a "compelling alternative" to direct electrical stimulation of nerves.

Dr. Cederna and coauthors write, "The ultimate goal is to develop a prosthesis that closely mimics the natural limb, both in its ability to perform complex motor commands and to elicit conscious sensation." While many research challenges remain to be met, they believe that newer techniques like TMR, sRPNI, and optogenetics "represent the wave of the future, paving the way to more intuitive prosthetic control through sensory feedback."

More information: "Providing a Sense of Touch to Prosthetic Hands" DOI: 10.1097/PRS.0000000000001289

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