Another step toward the hand prosthesis of the future

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The front and back of a human right hand. Credit: Wikipedia.

Researchers stimulated the nerves of an amputated arm with signals very similar to the natural ones, succeeding in "imitating the colors" of the evoked sensations of the various types of receptors and related nerve fibers present in the fingertips of the hand. This has brought greater realism and greater functionality of the feelings experienced by patients.

Over the years, various solutions have been developed to restore tactile information to people with limb amputation. However, this information is still far from those of the human hand in terms of naturalness and effectiveness. The solution to this important clinical and scientific problem is in a new research published in *Neuron*, one of the most prestigious journals in the field of neuroscience, by a group of researchers of the Sant"Anna School of Advanced Studies, of the École Polytechnique Fédérale de Lausanne (EPFL), of the University of Freiburg in Germany and of the Policlinico Gemelli in Rome. The working group coordinated by Prof. Silvestro Micera, professor of Bioengineering at the BioRobotics Institute of the Scuola Superiore Sant'Anna, and Bertarelli Chair in Translational Neuroengineering at the EPFL, has in fact developed a code capable of transmit for the first time to the nerves of the amputated arm all the variety of perceptions that it would have received from the nerve fibers connected to the tactile receptors of one's hand and then communicate the information useful for the movement in an extremely natural way.

The study, titled "Biomimetic intraneural sensory feedback enhances sensation naturalness, tactile sensitivity and manual dexterity in a bidirectional prosthesis," opens up new scenarios in the research on artificial prostheses and their ability to recover as much as possible the naturalness of the missing limb. Through an interdisciplinary approach, which integrates practices deriving from neuroengineering, clinical neurology, and robotics, with computer simulations of the behavior of neurons, it was possible to ascertain that by stimulating the peripheral nerve with information very similar to those that natural finger sensors would provide under normal conditions, the patient is able to receive more natural and effective information.

"In this work, we did not start from the robotic hand—explains Giacomo Valle, a doctoral student at the Sant"Anna School of Advanced Studies and first author of the study—but from the source of tactile information,

trying to reproduce the dynamics of the natural sensors and nerve fibers that spread from the fingers when a hand touches an object. In this way, we transmitted a signal to the patient's nervous system that was immediately recognized as natural."

This is a significant step forward towards an even more natural hand prosthesis because for the first time all aspects of tactile perception are taken into account. Furthermore, the code developed by the authors of the study can be applied to all prosthetic models, ensuring the sensitivity of perceptions and the effectiveness of movements.

"Our results will allow prostheses to be both effective and usable in a natural way and not felt like a foreign body. This will significantly increase the clinical impact of these technologies," says Silvestro Micera

The use of the code allows greater sensitivity when the robotic hand comes into contact with an object, exceeding the "sensory" limits of traditional prostheses.

"Our hand allows us to explore the environment around our person and interact with it. It allows us to hit hard or to stroke. It allows us to play a keyboard or lift a heavy barbell. All this variety of actions (and a thousand others) is also possible thanks to the sensory information that every movement and contact with an object sends to our nervous system. Losing sensory information is like living in a world without colors and without light / dark contrasts," said Prof. Paolo Rossini, clinical principal investigator of the study.

"Being able to feel sensations in a phantom limb, or in a hand that no longer exists is a significant step forward towards the development of truly functional prostheses. For the first time, I perceived the prosthesis as a natural extension of my body and not as an external part." said Loretana Puglisi, one of the patients.

More information: Giacomo Valle et al. Biomimetic Intraneural Sensory Feedback Enhances Sensation Naturalness, Tactile Sensitivity, and Manual Dexterity in a Bidirectional Prosthesis, *Neuron* (2018). DOI: 10.1016/j.neuron.2018.08.033