

Helping amputees feel as though their prosthetic limb belongs to their own body

14 August 2018

The famous idiom "seeing is believing" is not enough to help amputees with the use of their prosthetic limb. Many amputees opt out of prolonged use of their prosthetic limb because their perception of their missing limb simply does not correspond to their prosthesis. In other words, their own perception of the missing limb, or the brain's representation of it, does not match up with what they see of the prosthesis.

The underlying problem is twofold. Amputees still have a mental perception of their missing limb, even though it is physically gone, and this so-called [phantom limb](#) is often perceived as much smaller than the lost limb. Next, commercially available [prosthetic](#) limbs do not yet provide sensory feedback other than what the patient sees, meaning that the patient has no sense of touch from the [prosthetic limb](#) and must constantly watch it for correct use.

Tricking the brain to embody the prosthetic limb

Now, in a scientific collaboration led by EPFL (Ecole polytechnique fédérale de Lausanne), scientists show that amputees can actually be convinced that the prosthetic [hand](#) belongs to their own body. They do this by exploiting the "seeing is believing" idiom based on established research on how the brain identifies what belongs to its own body. Instead of using the sense of sight alone, they used a combination of two senses: sight and touch. The results are published today in the *Journal of Neurology, Neurosurgery & Psychiatry*.

"The brain regularly uses its senses to evaluate what belongs to the body and what is external to the body. We showed exactly how vision and touch can be combined to trick the [amputee's](#) brain into feeling what it sees, inducing embodiment of the prosthetic hand with an additional effect that the phantom limb grows into the prosthetic one," explains Giulio Rognini of EPFL's Laboratory of

Cognitive Neuroprosthetics led by Olaf Blanke, in a collaboration with Silvestro Micera of EPFL and Scuola Superiore Sant'Anna in Italy. "The setup is portable and could one day be turned into a therapy to help [patients](#) embody their prosthetic limb permanently."

In two hand amputees, the scientists provided artificial tactile sensations at the tip of the phantom index finger by stimulating the patient's nerve in the stump. At the same time, the patient wore virtual reality goggles which showed the index finger of the prosthetic limb glowing in synchrony with the administered touch sensations. This combination of [virtual reality](#) with artificial tactile sensations takes the rubber-hand illusion to another level.

Both patients reported feeling as though the prosthetic hand belonged to their own body. Moreover, when asked to evaluate the position of their hands, both patients felt as though their phantom limb had extended into the prosthetic limb. Previous to the experiment, they both reported that the phantom hand was small and directly connected to the stump, as if the phantom limb had no forearm, a change in size referred to as "telescoping" in scientific jargon. In fact, their phantom limb extended during the experiment, and remained extended for up to 10 minutes afterwards.

The experiment simply requires the patient to passively observe two sensations on the fingertip, the visual glow and the artificial touch happening in synchrony, in order for embodiment and extension of the phantom [limb](#) to take place. This is the first time that the principles of multisensory integration have been tailored to provoke embodiment of the prosthetic hand and reduction of telescoping, exploiting in particular the integration of bodily multisensory information to create the coherent experience of having a body.

The study builds upon research that opened new avenues in prosthetics. In 2014, in a European

collaboration led by EPFL, scientists overcame a major hurdle by giving an amputee the ability to feel in real-time with their prosthetic hand. Information about touch coming from sensors at the prosthetic fingertips were directly processed and relayed into the nervous system via electrodes that were surgically wired to the stump's main nerves. The potential of this technology is still being explored, and in 2016, the scientists showed that the enhanced prosthetic technology could even help the same amputee detect differences in texture.

More information: Giulio Rognini et al, Multisensory bionic limb to achieve prosthesis embodiment and reduce distorted phantom limb perceptions, *Journal of Neurology, Neurosurgery & Psychiatry* (2018). [DOI: 10.1136/jnnp-2018-318570](https://doi.org/10.1136/jnnp-2018-318570)

Provided by Ecole Polytechnique Federale de Lausanne

APA citation: Helping amputees feel as though their prosthetic limb belongs to their own body (2018, August 14) retrieved 17 June 2022 from <https://medicalxpress.com/news/2018-08-amputees-prosthetic-limb-body.html>

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