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A more human prosthetic hand

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Subject: Prosthetics

Title: A more human hand

One sentence abstract:

Co-design leads the way for bio-inspired prosthetics with improved design and performance

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There has been substantial progress towards the development of multifunctional upper-limb prostheses, however, the clinical reality of these devices has barely changed. Many people with limb absence choose to not wear a prosthesis or abandon their device shortly after fitting with the primary reason being that it does not provide enough function (1). Users cite prosthesis comfort and aesthetics as well as psychological support during the treatment as other factors. The need to develop advanced prosthetic solutions is clear and reinforced by appropriate care models. Writing in *Science Robotics* Laffranchi *et al.* (2) present the Hannes hand. Not only does the prosthesis resemble a human hand physically, it also offers biomimetic grasping, closely following natural movement kinetics and joints kinematics patterns of a human hand. They detail the design, implementation, control and testing of the Hannes hand and carry out a pilot clinical trial involving three subjects.

Acknowledging user needs and inspired by the classic work of Santello *et al.* (3), the authors designed the Hannes hand to reproduce the principal movements of the natural hand, e.g. full grasp. The researchers moved away from the popular believe that prosthetic hands need to mimic the movements of all joints (>20 degrees of freedom). They approximated these principal movements using the principal component analysis method and observe that the first two principal movements of both Hannes and natural hands match reasonably well in terms of the opening-closure of the hand by the four fingers, see Figure 1. Differences emerged when analysing the movement of the thumb; the abduction/adduction movement of the natural hand led to thumb flexion/extension on the Hannes hand. Three individuals with limb difference wore and tested the Hannes hand with a 2-channel electronic interface that recorded the activity of the stump muscles, the so-called myoelectric signals. They completed several conventional prosthetics clinical tests and questionnaires before and after two-weeks (approximately), during which they wore the prosthesis continuously for their activities of daily living. Two of the three participants showed notable improvement in test scores, excluding those metrics that specifically measured thumb function, either because of the technical challenge or the lack effective thumb abduction representation by the Hannes hand.

The value of the work presented by the authors extends beyond their immediate use of a new prosthetic hand in rehabilitation. Dyson *et al.* (4) and Segill *et al.* (5) proposed the Abstract/Postural control paradigm. They argued that with practice, arbitrary functional mappings between stump muscle activity and discrete prosthesis functions (i.e. grips) can be learned by users. The Hannes hand can enhance this approach because it provides direct access to principal movements of the hands within a continuous control space.

The translation of myoelectric control research into clinical benefit has been notoriously slow. Commercialization is rare and most innovations have remained within academia, thus the rate of

device abandonment has not reduced. In addition, laboratory-based metrics and findings do not always predict the outcome of long-term home trials and clinical investigations, where experimental constraints are relaxed (6,7). In the work of Laffranchi and colleagues (2), the best performance improvement was achieved by participant 1, who had the longest experience of using myoelectric prosthesis (48 years) as well as the use a multi-articulated hand. An outstanding challenge for prosthetics research is to distinguish between the benefits of the prosthesis' technical innovation from any potential gains that originate from the users' general prosthetics control experience.

Laffranchi and co-workers (2) indicate that the Hannes hand was co-developed "organically by researchers, patients, orthopaedists and industrial designers". Although they do not shed more light in this paper as to *how* such co-creation was achieved, it is clear that prosthesis users can play a critical role in identifying new prosthetic research topics as well as the development of future prosthetics care and delivery models. The future of co-creation (8) in upper-limb prosthetics depends on forming an inclusive platform that nurtures collaboration. Considering input from users along with clinicians, industry experts and policy makers. It is hoped that by broadening participation, users will find the next generation of prosthetic hands more fit for purpose.

Figure 1. **Hannes hand and its principal movements:** A) the closing of the four fingers; B) closing of the distal joints of the fingers as well as the adduction of the thumb; C) partial rotation and abduction of the thumb.

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