Federal Ministry
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Digital and
Economic Affairs

Christian Doppler
Forschungsgesellschaft

Where humans and technology meet

The development of thought-controlled prostheses needs not only technical perfection but also medical expertise. The remaining nerves and muscles must be connected so their signals can be used by high-tech prostheses.

The topic

Highly developed modern prostheses can perform a wide range of movements. But despite considerable technological progress, it is still vital that the human can control the prosthesis. From the start of the millennium the connection between human and prosthesis has been based on TMR operations (targeted muscle reinnervation): the nerves that transferred signals to the natural arm are connected to the remaining muscles at the site of the amputation. The prosthesis can recognize activation of the muscles and use the signals to perform appropriate movements. This makes operation of the prosthesis more intuitive – the nerves for hand movements stay the same.

The research question: nerve transfer for intuitive control

Putting this into practice requires wide-ranging and highly specialized medical knowledge. Where exactly do the nerve tracts run – and in which direction? And where are the muscles that can pick up the stimulation of the nerve and transmit it to the prosthesis? Amputations above the elbow pose a particular challenge as it is necessary to replace not only the

CD Laboratory for Restoration of Extremity Function

Head
Univ.Prof. Dr Oskar Christian Aszmann

Operation
01.01.2012 – 31.12.2018

Commercial partner
Otto Bock Healthcare Products GmbH

Three questions to ...

Dr. Andreas Goppelt
CTO and Director of Ottobock's Vienna office

Why is basic research so important for innovation?
Without knowledge of the biological mechanisms, we cannot develop new concepts to treat patients who have lost extremities or suffered lameness in them. The innovative methods we have developed include selective nerve transfer and pattern recognition algorithms to control prostheses.

What are the biggest challenges in collaborating with universities?
Apart from the different expectations – "publish v. patent" – the level of interdisciplinarity is a particular challenge in our collaboration. It is vital for the partners to exchange information so that we can bridge the gap between medicine and technology.

What do you like most about the CD Laboratory funding scheme?
CD Laboratories give us the chance to try out various techniques and methods that are at such an early stage that we cannot possibly predict whether they will work. The 50% level of support provided to the CD Laboratory also lets us pursue approaches that would simply be too much of an economic risk without such backing.

function of the hand but also that of the elbow. The upper arm contains only two distinct muscles, the biceps and the triceps, to perform this complex control. How and precisely where can muscle activity be best measured? And how can the brain pick up signals that come back from the prosthesis, for example relating to how tightly an object is being held (feedback function)?

Collaboration in the CD Laboratory

Further development of the method requires close collaboration between prosthesis manufacturers and medical research: biological signals from nerves and muscles must be found and made useful. The prosthesis must pick up the biosignals in an appropriate way and there is a need for new rehabilitation concepts to enable the patients to use the full capabilities of their prostheses. In Prof. Aszmann of the Department of Plastic and Reconstitutive Surgery at the Medical University of Vienna, Ottobock has an ideal partner with extensive scientific expertise. His work contributed to the first operations of this kind in the USA and in 2006 he became the first person – even then with the support of Ottobock – to perform the operation outside the USA. In the meantime, a large-scale research network has grown up around the CD Laboratory and the company partner is fully integrated in it.

Results

The CD Laboratory and its network has produced extensive new knowledge on the position and function of the nerves that control arm movements. Thanks to its collaboration in the CD Laboratory, the company is at the cutting edge of science and its advance knowledge is extremely beneficial to the further development of its products. Ottobock is now able to offer prostheses that are highly controllable when connected to a TMR operation, able for example to recognize several signals to determine which precise movement to perform. The signals from nerves and muscles can be measured directly in the body by means of implantable sensors that are less subject to interference, for example by sweating. New knowledge on the direction of stimulus transfer in the nerves is enabling fresh approaches to the feedback function. A large number of publications in top-quality journals attest to the success of the CD Laboratory, which was also recognized by the EU's award of an ERC Synergy Grant to Prof. Aszmann in 2018. The collaboration will continue beyond the completion of the CD Laboratory's operation in 2018.

Scientific challenge

The comprehensive care of patients with prostheses requires an interdisciplinary approach. The necessary knowledge ranges from the underlying anatomy and neurology through operational methods and robotics to appropriate concepts for rehabilitation. The first anatomists examined the position of the nerves in the arm as far as possible by means of dissection but modern anatomical and neurobiological research is also based on histological staining and new methods in immunohistology. As an example, a method developed in the CD Laboratory has enabled motor and sensory nerves to be distinguished from one another. Extensive knowledge of the nerves in the arm will also be valuable to other areas of medicine, for example when amputation is not necessary.

Added value for the company

The method of selective nerve transfer into other muscles has been refined and patients can now benefit from it as a standard of care, not only in the Vienna General Hospital. New rehabilitation concepts for TMR prostheses have been developed and are on the market and initial solutions to the problems of better pattern recognition will be marketed in 2019. The first steps towards products with an improved feedback function have been taken and two patents have been registered.

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