Medical Xpress

Novel electrode systems unveil the mechanisms behind human movement

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For researchers in the fields of robotics and prosthetics, replicating the subtle combination of mechanisms underlying our movements is both an exciting and difficult challenge. Scientific efforts under the DEMOVE project have resulted in new electrode systems that are able to do just that.

As simple as it seems, the fact of moving our arm and hand to seize an object is the result of complex events taking place in our brain, spinal cord, nerves and muscles. These so-called discrete events include ion exchanges across membranes, electrochemical mechanisms, and active ion pumping through energy expenditure that together form spike trains—the language in which the external world is encoded into our brains.

Recording and interpreting this 'neural code' of movements was at the heart of the DEMOVE (Decoding the Neural Code of Human Movements for a New Generation of Man-Machine Interfaces) project. While previous scientific efforts were faced with the impossibility to detect and process the activity of motor neurons and the neural code in intact humans, Prof Dario Farina and his team from the University of Göttingen developed novel electrode systems to fill this gap.

These new systems provide in-vivo electrophysiological recordings from nerves and muscles in humans as well as new computational methods and models for extracting functionally significant information on human movement. They help answer open questions in movement neuroscience, build a bridge between the neural and functional understanding of movement, and are hoped to enable new forms of man-machine interaction.

How do you explain the current lack of solutions to monitor movement-related neuronal activity in intact humans?

Accessing neurons in the central nervous system implies inserting electrodes into the human body and penetrating neural structures (e.g., the motor cortex) with the risk of damage. The surgical procedures for these interventions are complex and risky. Moreover, non-invasive techniques (e.g., MRI, MEG or EEG) lack the required selectivity to decode the complexity of the neural activity during movements.

How do your electrode systems allow you to overcome these problems?

We record activity from muscles using muscle tissue as a biological amplifier of nerve activity. Indeed, when nerves connect to muscles, their neural activity is preserved and can be decoded from the electrical activity of the corresponding muscle. This means that although we record from the periphery of the system (from muscles), we are able to identify the output from the spinal cord circuitries whose activity determines the movement.

What can you tell us about the results of your project so far?

The project will finish at the end of June this year. It has produced outstanding results in all analysed disciplines. For example, the recording systems we developed allowed us to re-analyze critically the hypotheses made approximately 80 years ago on motor neuron control during movement.

The new recording systems provide the possibility to decode the activity of large populations of motor neurons and separate the information of the central nervous system from the peripheral mechanisms. Results also advanced the field of neuro-mechanics by revealing the mechanical forces produced by neural structures, as well as the field of man-machine interfacing by providing intuitive and robust methods to control myoelectric prostheses.

What were the main difficulties you faced and how did you overcome them?

The project is high risk, high gain, and therefore we have faced many challenges. Nonetheless, all of these challenges have been addressed with team spirit and none has resulted in major hurdles. Examples of such challenges included the need to record activity from a large number of muscles simultaneously, the concurrent decoding of large motor neuron populations in vivo and the use of these techniques in order to control myoelectric prostheses.

The main potential outcome of your research lies in man-machine interaction. Could you provide examples?

We have proposed and proved the feasibility in this project of upper limb prosthetics fully controlled by the activity of tens of motor neurons, whose behavior has been decoded from muscle recordings, also thanks to advanced surgical procedures.

With only a few months to go before the end of the

project, what do you still want to achieve before and after its end?

Promoting the motor neuron control in man-machine interfacing as a means for extremely accurate and clinically viable control will be our main focus.

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