Cortico-spinal interactions during recovery of hand function following spinal cord injury:

from methods development to clinical application

Spinal cord injury (SCI) arises from focal insults to the central nervous system that typically result in paralysis of hand/arm function. Pathophysiologically, in addition to focal changes at the lesion epicenter, a SCI produces also remote and progressive neurodegenerative changes. Current clinical evaluations are focused (temporally and spatially) on the extent of the focal spinal injury, while neglecting interactions between spinal and supraspinal neuronal circuits. This calls for a more comprehensive understanding of the synergies between supraspinal and spinal networks involved in the control of hand movements following SCI. A better understanding of these pathophysiological processes offers an important avenue and basis for individually focused treatment. A mechanistic quantification of the recovery of hand movements will be achieved by quantifying functional interactions between hierarchically related supraspinal, spinal and peripheral nervous systems, simultaneously. One exciting new approach to achieve this is to supplement the established clinical and electrophysiological assessments with **ultra-high-field (UHF) MRI** and Optically Pumped MagnetoElectroencephalo-Spinography **OP-MESG**. UHF provides the decisive advantage of sub-millimeter resolution imaging with higher signal- and contrast-to-noise ratios. OP-MESG on the other hand allows these functional interactions between brain and cord to be measured at high spatial and temporal resolution. The simultaneous acquisition of OP-MESG measurements from the brain and spinal cord would allow to evaluate the functional connectivity between neural circuits across several hierarchical CNS levels. To take full advantage of these technological opportunities to detect the microstructural-function interplay during recovery, both UHF-MRI and OP-MESG imaging and analysis methods need to developed and subsequently applied in a clinical setting.

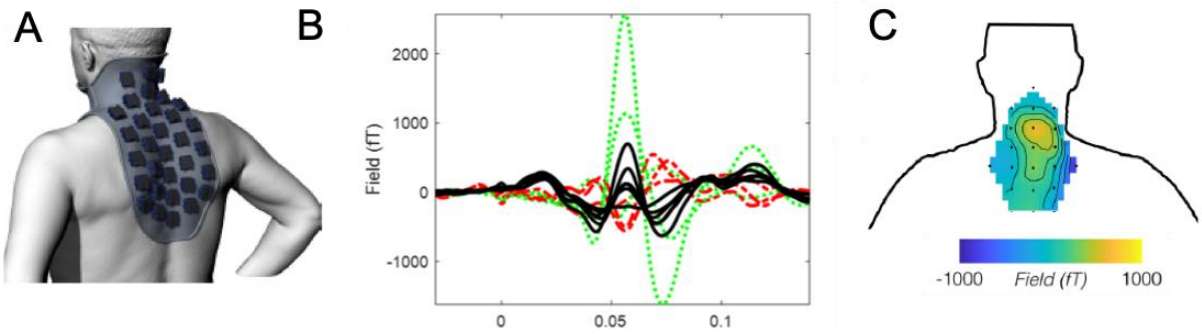

Figure 1. Pilot data recordings based on 1.6Hz electrical median nerve stimulation of the right arm. A. Prototype spinal arrays. B. Averaged evoked response from cervical channels. C. Field map of response in left-right direction.

Objectives and goals: This project will develop a combined UHF-MRI/OP-MESG approach that will ultimately provide a computational assay characterizing the mechanistic interaction between structure and function that occurs during the recovery of hand function following SCI across the brain and injured spinal cord, in-vivo. The simultaneous measurement of cervical and supraspinal neural circuit activity will enable assessment of the interplay between afferent and efferent pathways activated during neural coupling, as well as their interaction with proprioceptive input form the hands.

Your profile

- Study background in Biomedical Engineering, Computational Biology, Health Science, Bioinformatics, Neuroscience, Biomedical Science or an equivalent field
- A strong interest in medical image and signal processing
- Strong analytical skills
- Programming experience
- Good communication skills in English and German will be a plus
- Ability to think creatively and work independently
- A strong team player