Optimization and Experimental Validation of Coil Positions in Localization Studies Using Transcranial Magnetic Stimulation

Supervisors: Prof. Knösche, Dr. Weise

Non-invasive brain stimulation using Transcranial Magnetic Stimulation (TMS) is a useful tool to study the human brain. Recently, at the Max-Planck-Institute for Cognitive and Brain Sciences (MPI-CBS) in Leipzig, a method was developed to localize the TMS-activated neurons that are responsible for observed peripheral nerve/muscle activity. The measurement principle is illustrated on the right. Electrical muscle activity in the hand is measured for different stimulation intensities, coil positions, and coil orientations. Based on the numerically computed induced electric field, it is possible to establish the relationship between the electric field at each brain location and the observed peripheral effect (input-output curve; IO curve). For the brain region containing the neurons that are causal for the peripheral effect, this I/O curve should be the same irrespective of the coil position or orientation. Therefore, we quantify the congruence between the measured I/O curves. The hotspot region of this congruence map indicates the area of stimulated neurons. Currently, this method requires high experimental effort, because it rests on high variability of the electric field pattern between the different coil position and orientation. It is the goal of the thesis to develop an optimal stimulation scheme by applying selected optimization strategies to maximize the variability with minimum number of coil positions/orientation. The results will be verified against existing experimental and numerical results and validated with new measurements conducted in the TMS laboratories of the MPI-CBS in Leipzig.

The thesis will be conducted in cooperation with the MPI-CBS in Leipzig.

Tasks:
- Getting familiar with existing Python programs, which were developed at the MPI-CBS in Leipzig.
- Formulation of the optimization problem and selection of an appropriate optimization method.
- Implementation of a script based optimization scheme in Python by extending existing scripts.
- Experimental validation of the optimization results in the TMS laboratories of the MPI-CBS

Contact:
Prof. Dr.-Ing. habil. Thomas Knösche  
Max-Planck-Institut für Kognition- und Neurowissenschaften Leipzig  
Telefon: 0341-9940-2619  
Email: knoesche@cbs.mpg.de

Dr.-Ing Konstantin Weise  
Max-Planck-Institut für Kognition- und Neurowissenschaften Leipzig  
Telefon: 0341-9940-2580  
Email: kweise@cbs.mpg.de