In this study, we will investigate if the use of electric field simulations can lead to more accurate TMS targeting using data from the human connectome project. A priori knowledge will be used to define the cortical target (MNI - 38, 44, 26 (Fox et al. 2021) mapped to the individual T1-w MRI files). The coil position on the scalp is determined using the projection method. Subsequently, the TMS induced electric field distributions were computed using SimNIBS (Thielscher et al. 2015).

The region of the brain assumed to be affected by the stimulation was defined as the brain areas in which the electric field strength exceeded a threshold. This threshold varies between zero and the maximum induced electric field strength. At the conference, we will show an overview of percentage of subjects in which the predefined cortical target area falls within the stimulated region as a function of threshold derived from the electric field strengths, when the projection method is used for coil positioning. If these percentages are small, electric field simulations might be beneficial.

References:

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META-ANALYTIC ELECTRIC FIELD MODELING

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In this presentation, I will talk about our efforts in combining electric field modeling with traditional meta-analysis on the effects of tDCS on working memory. Due to differences in electrode montages and stimulation intensities across different studies, results are difficult to aggregate for meta-analytic inferences. To overcome these limitations, we have developed a novel meta-analytic method relating behavioral effect sizes to electric field strength, to identify brain regions underlying the largest tDCS-induced WM improvement. Simulations on 69 studies targeting left prefrontal cortex showed that tDCS electric field strength in lower dorsolateral prefrontal cortex (Brodmann area 45/47) relates most strongly to improved WM performance. This brain region could be a target area for future tDCS studies. Our metanalytic framework can be applied to other stimulation modalities and behavioral measures.

HIGH-PRECISION LANGUAGE MAPPING THROUGH MULTIMODAL fMRI, TMS AND E-FIELD MODELLING

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Introduction: Neurosurgery requires careful planning to minimize damage to eloquent brain areas. Combining Transcranial Magnetic Stimulation (TMS) with frameless stereotactic neuronavigation and MR imaging allows for image-guided stimulation with high precision. While TMS is increasingly used for preoperative mapping of language areas, standard TMS mapping approaches lack the accuracy of direct cortical stimulation. We propose an optimised procedure for language mapping bringing together fMRI, TMS and improved estimation of effective stimulation targets by combining electrical field (E-field) modelling with precision neuronavigation.

Methods: We evaluated our newly developed multimodal precision mapping in a sample of healthy subjects. An fMRI task was administered to functionally localize language eloquent areas in the brain. For each subject, the fMRI data was used to define a language 'hotspot' in the superior temporal gyrus (STG). TMS-bursts of 10 Hz were applied to a circular grid around this hotspot while subjects performed an object naming task. Images were displayed on a screen and TMS bursts were administered after image onset. The E-fields of coil positions that effectively interfered with speech, i.e. resulted in a speech arrest, were calculated using SIMNIBS.

Results: For all subjects, language fMRI resulted in activity in the STG. TMS around the language hotspot-grid evoked speech arrests in all subjects. Mean effective E-fields and fMRI activation maps were found overlapping. The overlap indicates the causal area leading to speech arrests and thus highlights the most important language eloquent area.

Conclusion: We herein demonstrate that TMS may be used as a mapping approach for functional localisation studies. The approach presented in this study used E-field simulation of TMS fields to generate maps of the E-fields effective for function disruption. This method allowed for verification of causally involved speech eloquent areas. Presurgical planning may benefit greatly from the proposed multimodal mapping procedure.

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NEW TOOLS TO MONITOR AND OPTIMIZE TMS TARGET ENGAGEMENT

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Recent advances in neuroscience-informed brain stimulation therapy have shown the great potential of patient-specific measures acquired before treatment (Cole et al. 2021, Weigand et al. 2018). Techniques for demonstrating brain stimulation target engagement are among the most promising developments in order to ensure treatment suiting the individual patient's needs. This symposium highlights different techniques to monitor the acute effects of stimulation as they happen.

Martin Tik (Stanford University) will demonstrate that recent innovations in concurrent TMS/fMRI enable continuous image data acquisition during effective clinical stimulation protocols. This allows for direct insights into the therapeutic effects in an individual patient's brain.

Shanice Janssens (Maastricht University) uses a pioneering simultaneous TMS-EEG-fMRI setup to investigate how the individual oscillatory brain state impacts on signal propagation of TMS within targeted brain networks. This is a promising approach for improving individualized TMS depression protocols.

Hanneke van Dijk (Brainclinics Foundation) developed a deep learning (DL) model using a large subset of the TD-BRAIN+ dataset, consisting of EEG recordings from adults in a ground-truth scenario – sex classification. In a subsequent transfer learning scenario, the model enabled predicting MDD treatment outcomes with accuracies up to 78% based on individual EEG recordings. Methods of model interpretation and future applications of DL predictive models will be presented and discussed.

Jord Vink (University Medical Center Utrecht) will focus on the direct effect of single TMS pulses delivered to the left DLPFC in healthy participants using concurrent TMS/fMRI to learn more about the mechanism of action and a potential connection with the subgenual anterior cingulate cortex. Moreover, a novel method for TMS target engagement in the treatment of depression will be discussed.

References:

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