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.

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FUNCTIONAL CONNECTIVITY- AND E-FIELD-OPTIMIZED TMS TARGETING: A PILOT TMS-FMRI VALIDATION AT THE SINGLE-SUBJECT LEVEL

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Effectiveness of personalized, functional connectivity (FC)-guided TMS treatments (Cole et al. 2021) can profit from optimizing coil position and orientation based on E-field simulations. However, existing optimization routines (e.g., SimNIBS; (Saturnino et al. 2019)) typically only consider the E-field in a small patch surrounding a single target coordinate, thus ignoring whole-brain topography of both subject-specific FC map and E-field. To increase target specificity of FC-guided TMS, we developed an optimization approach that takes into account the available spatial information and tested its validity in a single-subject TMS-fMRI experiment, indirectly targeting ventromedial prefrontal cortex (vmPFC) via its FC with left dorsolateral prefrontal cortex (LdlPFC).

Using SimNIBS, we simulated TMS-induced E-fields for multiple coil positions and orientations surrounding an individualized, vmPFC-anticorrelated LdlPFC coordinate (Figure 1B+C). Within our approach, the optimal combination of coil position and orientation simultaneously maximized (Cole et al. 2021) overlap between E-field and negative FC cluster in LdlPFC and (Saturnino et al. 2019) E-field strength in the target cluster, while minimizing overlap with non-target (e.g., positive FC) areas (Figure 1C). For concurrent TMS-fMRI, we used two TMS-compatible 7-channel RF surface coil arrays and a MR-compatible TMS coil that was neuronavigated to the optimized position and orientation (Figure 1A). TMS pulses were applied during gaps between volumes at suprathreshold intensity.

Our optimization approach resulted in a very good overlap between subject-specific vmPFC-based FC map and simulated E-field, with minimal off-target coverage. Concurrent TMS-fMRI revealed specific TMS-induced BOLD modulations in both the directly stimulated LdlPFC target area and the indirectly targeted bilateral vmPFC (Figure 1D).

Preliminary TMS-fMRI data indicates that our FC- and E-field-based TMS optimization approach ensures precision and specificity of stimulation-induced brain activation in both directly targeted and functionally connected regions. We will further validate this approach in a larger sample, yet concentrating on single-subject level evaluations. We hope that this approach will further increase specificity and effectiveness of personalized TMS.

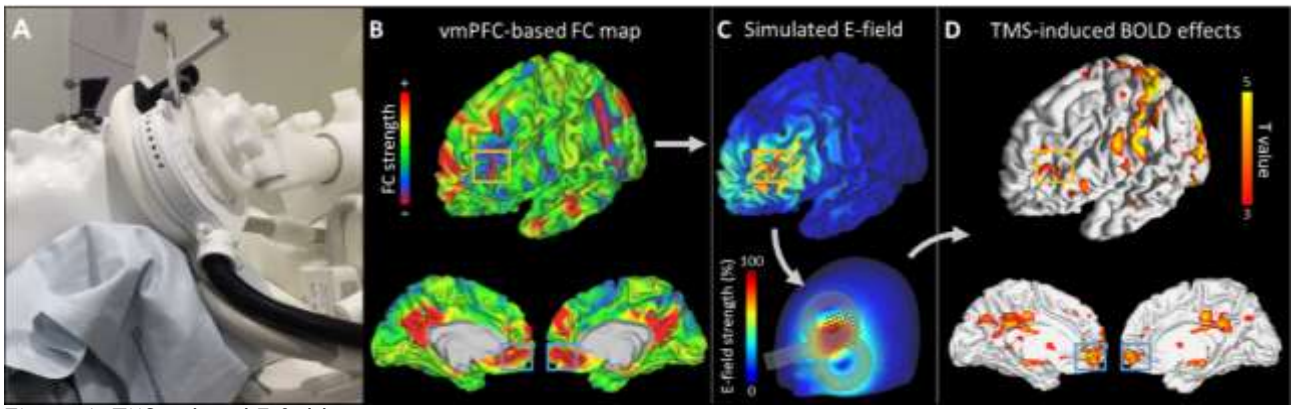

Figure 1. TMS-induced E-fields

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