Mapping human cortical excitability through coupling between robotized TMS and EEG

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Introduction

Measuring cortical excitability (CE) of the motor cortex is a mandatory step prior to any experiment involving transcranial magnetic stimulations (TMS), because it determines both stimulation dose and safety limits [1]. However, generalization of the motor CE level to other cortical areas is not straightforward because of the very specific cytoarchitecture of the primary motor cortex.

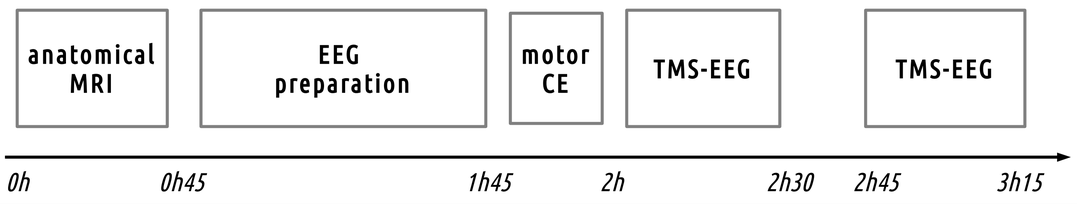
Combining TMS with concurrent electroencephalographic (EEG) recordings is a way to assess CE on any cortical areas, by studying the early components of the TMS evoked potentials (TEP) [2].

Aims

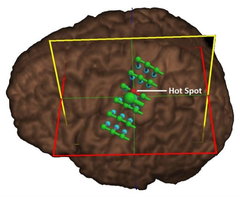
→ Developing a method **to map the TMS evoked EEG activity of the cortex**
→ Studying **the spatial homogeneity of the human CE**

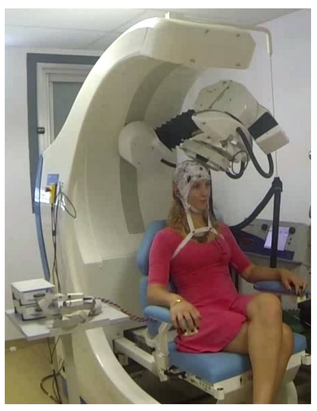
Materials & Methods

Protocol design



TMS parameters
→ Neuronavigated and robotized TMS
→ 18 cortical targets (9/hemisphere)
→ 80 single pulses per target (0.5-0.7Hz)
→ Intensity of 120%rMT (adjusted according to scalp-cortex distances)
→ rMT measured on the FDI hot spot





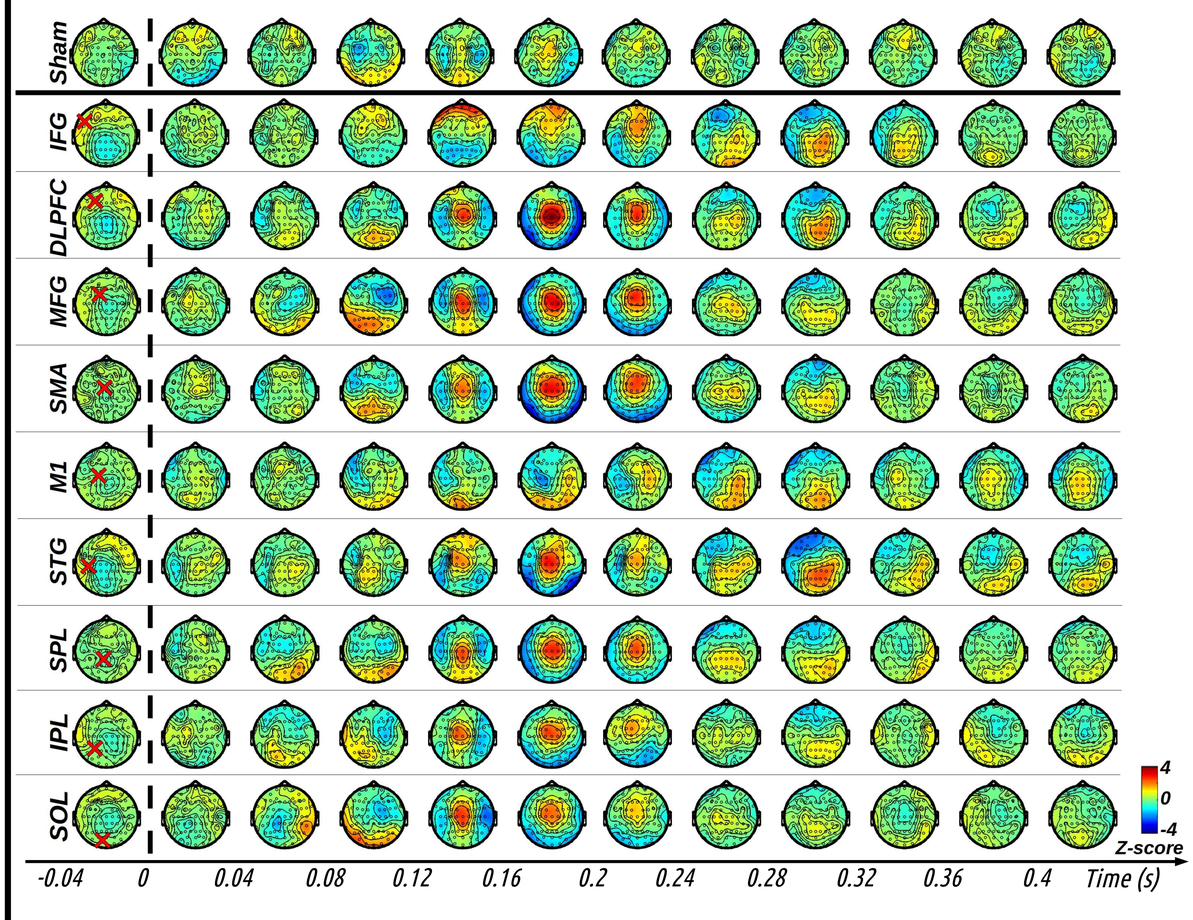
EEG parameters
→ 64 electrodes TMS-compatible cap
→ Sampling frequency: 512Hz

Others
→ 22 healthy subjects
→ Active noise-canceling earphone + white noise
→ Stimulation targets: IFG, DLPFC, Middle Frontal Gyrus, SMA, M1, Superior Temporal Gyrus, Inferior and Superior Parietal Lobes, and Superior Occipital Lobe

EEG signal processing

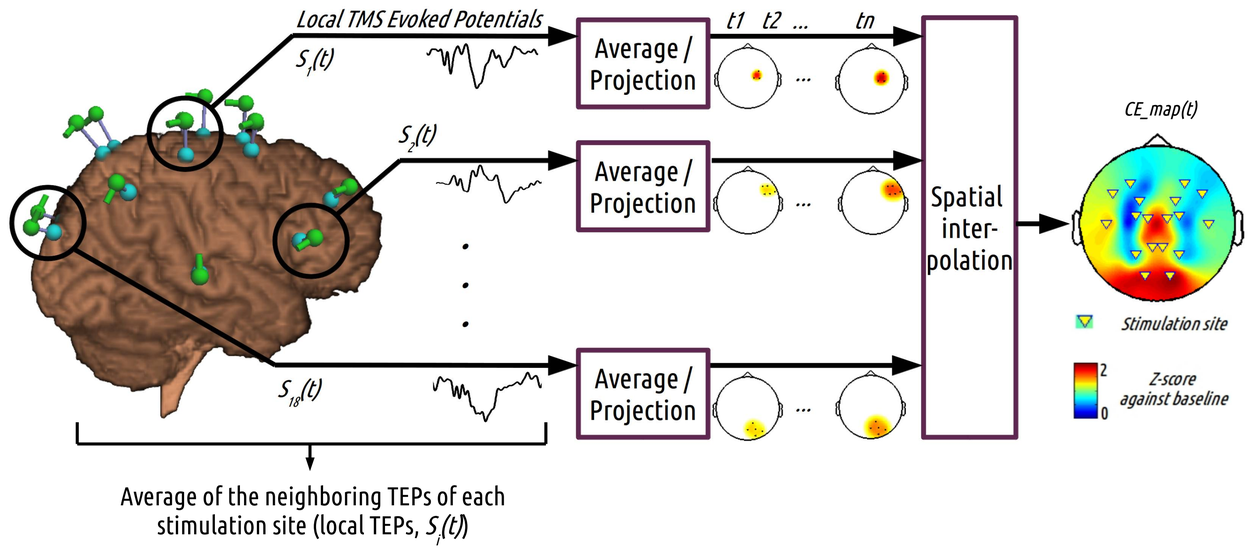
The EEG preprocessing was performed using the Fieldtrip toolbox for Matlab, and following the methodology described in [3], using two rounds of ICA.

Computed TEPs showed spatio-temporal patterns specific to each cortical target:



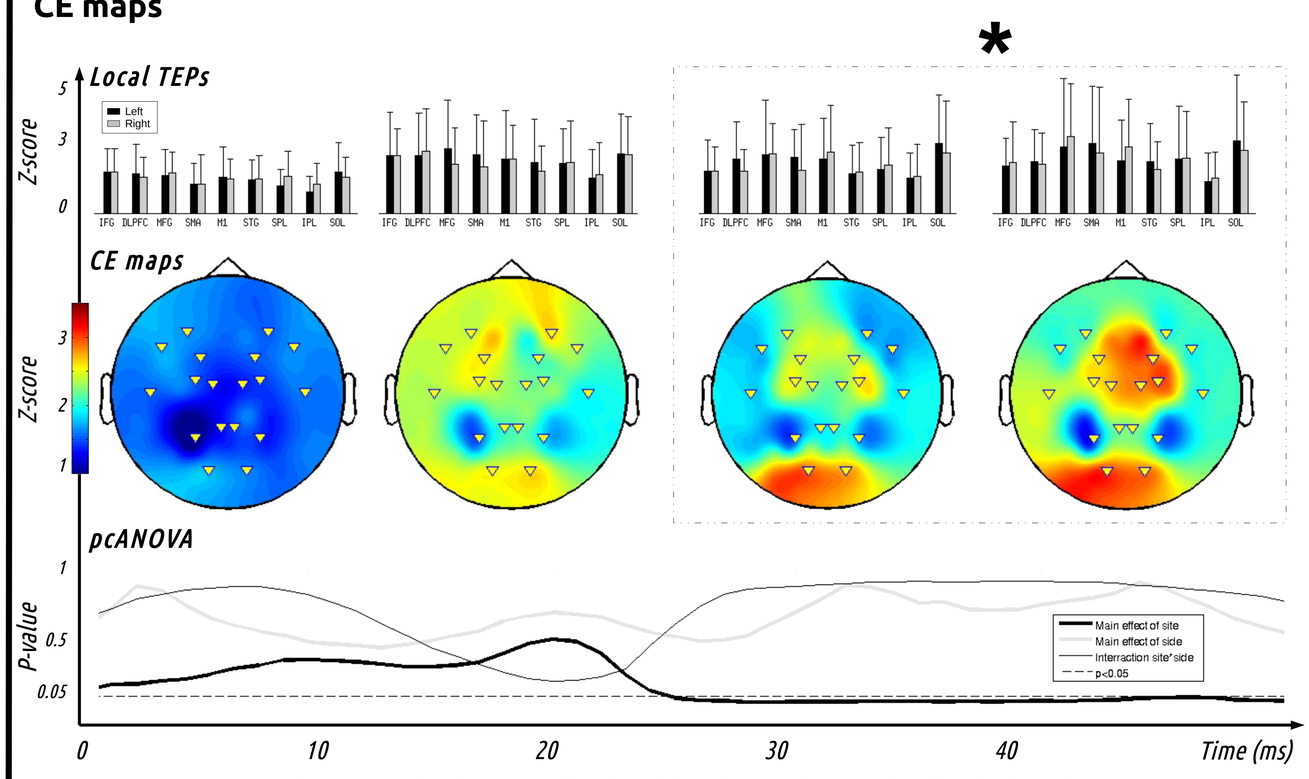
CE maps computation

Maps were computed using the following processing pipeline:



Results

CE maps

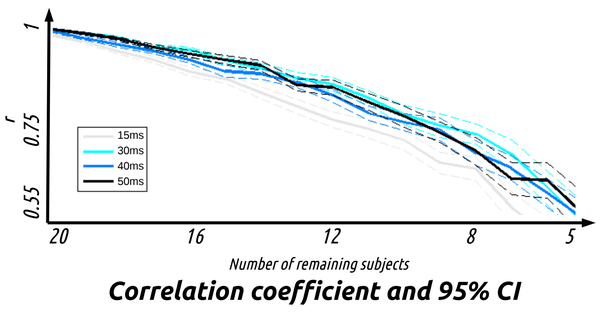


From top to bottom: absolute amplitude of local TEPs for each stimulation site, CE maps and continuous ANOVA results, against time

Local TEPs start to differ after 25 ms, where there is a significant effect of the stimulation site, regardless of the stimulation side.

Maps variability and reproducibility

Tested through the correlation product between the original local TEPs, and TEPs obtained with random subsets of subjects.
Good reproducibility (r>0.9) achieved for groups of at least 13 subjects (r=0.75 for groups of 9).



Correlation coefficient and 95% CI

Conclusion

Mapping feasibility

→ Cons: - expensive in terms of time and budget, regarding the whole procedure
- preprocessing not fully data driven (choice of ICs to be rejected)
→ Pros: - the mapping in itself can be done in a fast and convenient way
- low inter-subject variability

Human CE maps

The earliest components (0-25ms) are spatially homogeneous, but caution must be taken for the 0-15ms period (TMS artifacts), whereas the latter components (25-50ms) are spatially inhomogeneous, although activity from other intra-hemispheric connections might already be present [4].

→ This mapping could bring useful information about regional differences in cortical excitability. It could be turned into a biomarker of cortical reactivity integrity.

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