THE IMPACT OF ARTIFACT REMOVAL METHODS ON TMS-EEG SIGNAL

Giacomo Bertazzoli[1 2], Romina Esposito[1], Tuomas Mutanen[3], Clarissa Ferrari[4], Risto J. Ilmoniemi[3], Carlo Miniussi[1], Marta Bortoletto[2]

[1]Cognition Neurostimulation & Connectivity Lab, Center for Mind/Brain Sciences CIMeC, University of Trento, Rovereto (TN), Italy

[2]Neurophysiology lab, IRCCS Istituto Centro San Giovanni di Dio Fatebenefratelli, Brescia, Italy

[3]Department of Neuroscience and Biomedical Engineering, Aalto University, Espoo, Finland

[4]Statistical Service, IRCCS Istituto Centro San Giovanni di Dio Fatebenefratelli, Brescia, Italy

Transcranial magnetic stimulation combined with electroencephalography (TMS–EEG) is a powerful tool to investigate brain connectivity. The application of TMS allows for a causal and non-invasive interaction with brain activity, which can be recorded with a millisecond precision though the EEG. However, the cost of delivering TMS during EEG registration is the generation of artifacts that often mask the brain signals. Recent technical improvement in the EEG instrumentation combined with appropriate experimental procedures have reduced the impact of these artifacts, but TMS-induced artifact cannot be completely excluded from EEG during recordings. To tackle this issue, several methodologies have been developed to attenuate or eliminate TMS-related artifacts from the raw signal before further analysis. These preprocessing methods are commonly used in TMS–EEG studies and, despite their differences, little is known about how the preprocessing phase impacts the resulting signal.

For the above reasons, we aim to compare four of the recently published preprocessing methodologies to clean the TMS-EEG signal, by describing their impact on the resulting TMS-evoked potentials (TEPs).

Our dataset was acquired from a single-pulse TMS–EEG experiment (two target areas, left inferior parietal lobule (IPL) and left dorsolateral prefrontal cortex (DLPFC) stimulated in two sessions in 16 participants). We analyzed the data with four preprocessing pipelines: (1) Automated artifact rejection for single-pulse TMS–EEG data (ARTIST), (2) TMS–EEG signal analyser (TESA, default pipeline), (3) TMS–EEG graphical user interface (TMSEEG), and (4) a pipeline consisting of source-estimate-utilizing noise-discarding algorithm (SOUND) and signal-space projection–source-informed reconstruction (SSP–SIR). Notably, we kept the common preprocessing parameters (filtering frequencies, resampling, baseline, etc.) constant across pipelines to highlight differences inherent to their different algorithms.

Results on TEPs derived from different preprocessing methods revealed differences in amplitude spanning the whole epoch, for both IPL and DLPFC, and for both sessions. Spatial and temporal correlations of TEPs derived from different preprocessing methods were moderate-to-substantial at late latencies (> 100 ms), while lower values were found at early latencies (< 100 ms). Moreover, test–retest reliability of TEPs varied across preprocessing methods.

Taken together, these results suggest that the choice of the preprocessing method has a marked impact on the final TEP, even when the common preprocessing parameters are kept constant. This might add a source of ambiguity when comparing results from different TMS–EEG experiments. Further research is needed to reduce the variability of the preprocessing phase in the TMS-EEG analysis.