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MEG/EEG single trial source estimates based on inter-trial priors in the time-frequency domain for source connectivity analysis

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Introduction

Analysing functional connectivity of neuronal sources based on MEG/EEG source estimates is a non-invasive approach to examine the brain functioning. In order to apply functional connectivity measures such as coherency and phase locking value (PLV) to evoked responses, which are highly non-stationary over time, the source activations and the respective complex-valued time-frequency distributions have to be estimated on a single-trial basis. However, due to the low signal-to-noise ratio of unaveraged data, the applicability of present source reconstruction methods to the study of single-trial MEG/EEG data is limited.

Methods

We apply the multi-trial time-frequency mixed-norm estimate (MT-TF-MxNE) for reconstructing single-trial source estimates, which is based on a composite multidimensional mixed norm prior in the time-frequency domain combining a sparse intra-trial prior and a smooth inter-trial prior. By thresholding the Gabor transform of the source signals, the intra-trial prior promotes spatial sparsity and temporal smoothness of the neuronal activity per trial. The inter-trial prior retains consistency of the respective sparsity structure in the time-frequency domain to impose stationarity over trials. Amplitudes and phases of the active time-frequency coefficients are allowed to vary in order to account for trial-to-trial variations. Thus, the MT-TF-MxNE computes single-trial estimates while regarding multiple trials simultaneously to increase the information content. The resulting sparse regression problem is a convex optimization problem, which is solved using the fast iterative shrinkage-thresholding algorithm. Subsequently, for analysing source connectivity, coherency, coherence and imaginary coherence, and the PLV can be computed using the reconstructed single-trial time-frequency distributions.

Results

The MT-TF-MxNE is applied to simulated MEG/EEG data showing its ability to reconstruct location, activation and time-frequency distribution of evoked neuronal activity for functional source connectivity analysis.

Conclusion

The results show that the MT-TF-MxNE is a promising source reconstruction approach for analysing evoked MEG/EEG data. Applying the MT-TF-MxNE to real MEG/EEG data is part of the future work.