IDENTIFYING NEUROVASCULAR COUPLING IN BRAIN NETWORKS THROUGH STRUCTURED MATRIX-TENSOR FACTORIZATION OF EEG-FMRI DATA

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ABSTRACT

In recent years, the focus in brain research has shifted from merely detecting active brain regions, to the mapping of neural networks, i.e. characterizing how information flows between regions. This more holistic view is key to a better understanding of normal or pathological brain processes in various interest areas, such as the mapping of resting-state brain activity and in the diagnosis of epilepsy. Spatiotemporal assessment of such networks is possible by simultaneously recording electroencephalographic (EEG) signals and functional magnetic resonance images (fMRI), thanks to the highly complementary resolution of these modalities in time and space, respectively. It is not straightforward to jointly analyze the resulting data sets, however, since both modalities measure multiple active neural processes, in an indirect way, and to a different extent. Hence, it is not well known to which degree the electrophysiological observations from EEG and the hemodynamic observations from fMRI are related. We propose a novel, data-symmetric blind source separation (BSS) technique to extract sources of neural activity from the multimodal measurements, which relate to whole-brain functional networks. By relying on a structured form of coupled matrix-tensor factorization (CMTF), we characterize these underlying sources in the spatial, temporal and spectral domain, and estimate how the observations in EEG and fMRI are related through neurovascular coupling. That is, we explicitly account for the intrinsically variable nature of this coupling, allowing more accurate localization of the neural activity in time and space. We illustrate the effectiveness of this approach, which is shown to be robust to noise, by means of a simulation study. Hence, this provides a conceptually simple, yet effective alternative to other data-driven analysis methods in event-related or resting state EEG-fMRI studies.