DOCTORAL THESIS

Improved localization of neural sources and dynamical causal modelling of latency-corrected event related brain potentials and applications to face recognition and priming

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Abstract

Event related potentials (ERPs) are obtained from noninvasive electroencephalograms (EEG) which measure neuronal activity of brain on the scalp. However, conventional ERPs derived by averaging of single EEG trials have strong latency variability and are smeared, resulting in blurred scalp topography, especially in late components of ERP. The smearing problem had been addressed by reconstructing ERPs after latency correction with a new EEG analysis method Residue Iteration Decomposition (RIDE), which was demonstrated in a face priming paradigm to improve distinctness in scalp topography (Ouyang et al., 2011). This thesis aims to (1) extend the benefits of RIDE to neural source space by localizing the neural generators of ERPs, thereby developing an integrated RIDE framework for improvement in source localization and causal modeling of effective source networks, and (2) apply the framework to the face priming paradigm for famous faces, to explore the dynamics of face processing and priming.

We localized sources through brain electrical source analysis for both conventional ERP and RIDE derived ERPs (RERPs). RERPs allowed localization of an additional motor execution source (Premotor Cortex, PMC), apart from 5 other common sources, of which 2 (Occipital Lobe, OL; Fusiform Gyrus, FG) were obtained from early activity (< 250 ms) and 3 (Mediotemporal lobe, MTL; Prefrontal Cortex, PFC; Anterior Temporal Lobe, ATL) from late activities (> 250 ms) of RERPs respectively. Priming effects, i.e., the difference between primed famous (PF) and unprimed famous (UF) face conditions in source waveforms (SWFs), were extended and enhanced in RERPs, especially for late sources. The priming effects revealed (1) the role of sources in each hemisphere that play in perception, memory and execution, (2) parallel processing of information in sources, (3) early processing in the right hemisphere, and (4) predominance of the right hemisphere in face recognition.

Results confirmed SWFs of RERPs as better choice for the dynamic causal model (DCM). Two candidate DCM models, forward (F) and forward-backward (FB) were outlined on each hemisphere with SWFs from PF and UF conditions of RERP data. Priming has tendency to facilitate the FB model in the left hemisphere. On the other hand, independent of model preference, priming strengthened a bidirectional connection between FG and PFC in both hemispheres; this indicates a strong role of FG in structural representation and of PFCs in controlling decisions about face familiarity. Priming modulates the pathway FG→MTL→PFC

differently in the two hemispheres, strengthening the involvement of MTL in the left hemisphere and weakening in the right hemisphere. This indicates proficiency of the left and right MTL in processing different aspects of facial information. Further, a backward connection ATL→PFC in the left hemisphere was found to be functionally relevant for both conditions in speeding up response time in individual subjects, reinforcing the role of PFC in executive functioning and ATL in naming of famous faces.

Thus, an integrated framework of source localization and DCM with RERPs allows a novel, comprehensive understanding of time resolved dynamics in face recognition and priming, thereby piloting prospects of its application to other experimental paradigms.

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