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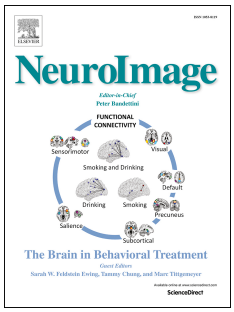


Robust and Gaussian spatial functional regression models for analysis of event-related potentials

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# Robust and Gaussian Spatial Functional Regression Models for Analysis of Event-Related Potentials

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**Abstract**

Event-related potentials (ERPs) summarize electrophysiological brain response to specific stimuli. They can be considered as correlated functions of time with both spatial correlation across electrodes and nested correlations within subjects. Commonly used analytical methods for ERPs often focus on pre-determined extracted components and/or ignore the correlation among electrodes or subjects, which can miss important insights, and tend to be sensitive to outlying subjects, time points or electrodes. Motivated by ERP data in a smoking cessation study, we introduce a Bayesian spatial functional regression framework that models the entire ERPs as spatially correlated functional responses and the stimulus types as covariates. This novel framework relies on mixed models to characterize the effects of stimuli while simultaneously accounting for the multilevel correlation structure. The spatial correlation among the ERP profiles is captured through basis-space Matérn assumptions that allow either separable or nonseparable spatial correlations over time. We induce both adaptive regularization over time and spatial smoothness across electrodes via a correlated normal-exponential-gamma (CNEG) prior on the fixed effect coefficient functions. Our proposed framework includes both Gaussian models as well as robust models using heavier-tailed distributions to make the regression automatically robust to outliers. We introduce predictive methods to select among Gaussian vs. robust models and models with separable vs. non-separable spatiotemporal correlation structures. Our proposed analysis produces global tests for stimuli effects across entire time (or time-frequency) and electrode domains, plus multiplicity-adjusted pointwise inference based on experimentwise error rate or false discovery rate to flag spatiotemporal (or spatio-temporal-frequency) regions that characterize stimuli differences, and can also produce inference for any prespecified waveform components. Our analysis of the smoking cessation ERP data set reveals numerous effects across different types of visual stimuli.

*Keywords:* Bayesian methods; Event-related potential; Functional data analysis; Functional mixed models; Functional regression; Correlated Normal-Exponential-Gamma.

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