

Simulating topographic distributions of
event-related potentials using Brisk

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We present an early version of an event-related potential (ERP) simulation tool written entirely in Python. Brisk (BRain Imaging Simulation Kit) currently enables users to simulate the topographic distribution of ERP activity over the scalp as well as control several aspects of between-subject variability in the activity of the underlying neuronal generators. Our aim is to develop a complete ERP phantom for use in research and education.

Electroencephalographic (EEG) recordings, especially when averaged across multiple experimental trials and multiple participants to reveal ERP signals, enable quantification of the relation between human cognition and brain activity. Analyses of ERP data revolve around complex statistical comparisons of ERP component properties, such as amplitude or topographic shape, between experimental conditions. Although simulation-based approaches are often adopted for justification and verification of ERP data analysis methods, the assumptions underlying the simulations are typically either identical to those inherent in a given data analysis method or simply not stated clearly enough to allow reproducibility. We aim to address both of these issues by providing a software tool which can be used as an ERP phantom – enabling reliable verification of data analysis methodology.

Our current focus has been on between-subject variability in topographic patterns of ERP activity. Most ERP studies rely on data collected from and averaged across multiple participants. However relatively little is known about the between-subject differences in neuronal generators, and hence topographic distributions of ERP activity. Typically simulations assume identical neuronal generator configurations across all subjects. All between-subject differences are assumed to be accounted for by normal noise with equal variance across all subjects and electrodes. Visual inspection of topographic distribution plots reveals striking differences between data simulated using the above described simulation methodology and ERP recordings collected in real experiments. We provide alternative approaches to ERP simulation, implemented within the Brisk software, that rely on variability in generator amplitude to better reproduce properties of topographic distributions of real ERP signals.

Although accurate simulation of EEG and ERP activity may yet require many years of research, we believe that in order to facilitate this research a working simulator, clearly stated assumptions, and their clean and easy to modify implementation are necessary. The presented early version of the Brisk simulator is a first step in this direction. Our long term goal is to include an intuitive graphical user interface that would enable both students and experienced ERP researchers to visually explore the parameters of the ERP simulation process, building intuitions about the brain and its relation to cognition along the way.