# Associating event-related brain dynamics with event context

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The goal of cognitive neuroscience is to model the relationship between brain activity and behavior and ultimately, the experience of active human agents who both create and respond to events in ‘real’ time, often without the luxury of delay. Until recently, however, in nearly all analyses of human event-related brain imaging data, the data were reduced to averages of trial epochs time locked to a pre-defined set of events. The event-related brain dynamics were then assessed by measuring the heights and/or trial latencies of peaks in the trial averages. This approach has two major drawbacks. First, not all the relevant statistical changes in EEG, MEG, BOLD or other brain signals are indexed by changes in trial average peaks, in particular characteristic changes in EEG spectral power time locked to meaningful events. Second, the assumption that brain responses to equivalent stimuli are themselves equivalent is at best doubtful, since each such event occurs in a distinct context including the recent stimulus and behavioral event history. A wealth of evidence suggests that ongoing EEG source signals and their event-related perturbations largely index the actions of processes that maintain or adjust the distribution of attention between sensory, mnemonic, and imaginative processes in response to the perceived significance of events – which may be heavily influenced by the context in which they occur.

To determine *from the data themselves* which event contexts are linked to which brain dynamic changes, we decomposed event-related log spectrograms from maximally independent EEG component (IC) processes time locked to delivery of auditory feedback signals in a ‘twoback with feedback’ visual working memory paradigm. Before decomposition of the (frequencies*latencies by trials) matrix for each IC, we appended a matrix of ‘answers’ to 19 questions about the trial context, in the form of a (questions by trials) matrix of (‘yes|no’) 1’s and -1’s. Maximally independent components of the joint data matrix gave independent factors (IFs) comprising a log spectral time/frequency modulation template, a loading on each of the 19 questions, plus a weight specifying the relative effect of the template in each trial.

Sorting the individual trial context vectors by their IF trial weights revealed significant across-trial trends, even for IFs predominantly linked to relatively simple event contrasts. For example, one IF for a central-midline IC was associated with reduced 3-Hz and 7-Hz activity during and following ‘Match’ button presses (relative to ‘Mismatch’ presses), followed by 4-Hz and 9-Hz activity increases before the delivery of the next letter. The effect, in single trials, of this ‘Match-versus-Mismatch’ IF was also slightly less positive (i.e., slightly more *Mismatch-like*) in both ‘Match’ and ‘Mismatch’ trials (a) in which the letter stimulus matched the immediately preceding (*one-back*) letter (foil trials), and/or (b) included a non-standard auditory feedback signal, and/or (c) in which a non-standard feedback signal had been received in the *previous* trial. This suggests that the upwards frequency shifts following Match responses, captured in the IF template, were attenuated in the presence of additional or conflicting current (or recent) events. Context ICA decomposition appears likely to allow new insights into the connection between events in context and the complex spatiotemporal patterns of local cortical field synchrony that produce the ongoing EEG. The approach should be applicable both in standard event-related paradigms, as here, or in yet more complex paradigms in which classes of equivalent events may be difficult to define *a priori.*

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