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Problems in estimating oscillatory phase of the EEG at stimulus onset

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Problems in estimating oscillatory phase of the EEG at stimulus onset

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The perception, cognition, and behavioural outcomes associated with a particular stimulus depend on the EEG state of the brain at stimulus onset. These effects have been considered in relation to the amplitude and phase of particular EEG frequencies or frequency bands. Originally, these were estimated using filtering (first analog, and then digital) to select a narrower (e.g., 1 Hz wide) or broader (e.g., 8–13 Hz alpha) frequency band. It has long been known that such filtering "smears" the amplitude data of each frequency over time, but the impact of this is often ignored. In essence, around the time of stimulus onset, the filtered output contains information from both prestimulus and poststimulus data. The poststimulus data is perturbed by activity evoked by the stimulus, and hence, as stimulus onset is approached in the prestimulus period, the poststimulus data contributing increases and this can substantially contaminate the prestimulus estimates. This problem also occurs in time–frequency analysis using FFT or wavelet approaches to frequency decomposition. Such methods use a window of data to estimate the amplitude and phase at the central point of the window, and advance the window in steps from the prestimulus beginning of the epoch through the time of stimulus onset to the end of the epoch. When the central point of the window is closer to stimulus onset than half thewindow length, contamination by poststimulus data begins. We believe that this has occurred in all previously-published analyses of phase at stimulus onset.

This presentation will illustrate this problem and our solution, using FFT time–frequency decomposition as an example. In an effort to avoid the problem, we take the last uncontaminated prestimulus data point, and extrapolate amplitude and phase forward to the time of stimulus onset. Using data from 20 adult participants in an equiprobable auditory Go/NoGo task, we used FFT with a sliding 250 ms 10% Hanning window and zero padding to resolve the EEG into 2 Hz bands. We calculated the usual phase at stimulus onset (such as those produced in EEGLAB and other time–frequency programs) in each of the delta, theta, alpha, and beta bands, and compared these with our uncontaminated phase estimates extrapolated from 125 ms before onset. Substantial differences indicate the impact of data smearing from the poststimulus period to the prestimulus period, arguing for the value of this new approach.