Variation of EEG source activities with reaction time in a visual attention task

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We recorded reaction time and electro-encephalographic activity from 15 subjects while they performed a simple visual attention task. One target position, out of five displayed along the horizontal axis, was cued continuously during 76-sec blocks. Subject had to respond whenever a disk appeared at the target position. Target location was balanced across blocks. In this poster, we consider responses to targets appearing at the cued location (about 500 trials per subject). These target trials included a typical 'P300' ERP peak.

Infomax Independent Component Analysis was applied to the concatenated single-trial data of each subject. The resulting independent components were then clustered across subjects, producing 6 clusters of artifactual components and 9 clusters of cognitive-related components, plus unclustered components. The 9 cognitive-related component clusters accounted for 87% of the grand-mean ERP. We characterized each component cluster in the time-frequency domain, assessed their contributions to the grand-mean ERP, and localized their equivalent dipoles. A far-frontal component cluster (1) contributed most of the onset of the P300 peak. A central parietal component cluster (4) contributed a third of the P300 peak amplitude and the remaining two thirds was mainly due to the contributions of left (5) and right mu (6) rhythm component clusters. Two frontal midline (2) and central midline (3) component clusters exhibited small response-locked peaks in their grand-mean ERP, constituting a wavelet in the theta frequency band at the latency of the P300 peak. Finally a central occipital alpha component cluster (7) also contributed to the P300 positivity and two lateral posterior alpha rhythm component clusters (left (8) and right (9)) made little contribution to the P300 peak.

For each component cluster, we then computed mean spectral phase and amplitude at each time point of each trial across a wide frequency range. We then constructed 2-D time-frequency correlation images between reaction time (RT) and EEG power, excluding trials with extreme RTs (5%-95%). We observed a strong correlation between spectral amplitude and reaction time (with p-values, corrected for multiple comparisons, down to 10^{-30}) in a variety of frequency bands including theta, alpha, beta and gamma. Some correlations only appeared for stimulus-locked trials, others for response-locked trials. Each independent component cluster exhibited specific correlation image features (in general correlation for one time-frequency point for one component cluster was not accompanied by a reverse correlation for another component cluster).

In most clusters higher alpha band power near the response moment correlated with longer reaction times. However, and surprisingly, the central parietal component cluster (4), accounting for the largest part of the response-locked P300, correlated weakly with reaction time compared to other component clusters. For the far frontal (1) and central alpha (7) clusters, an increase in theta amplitude about 100 ms before the reaction time correlated strongly with faster reaction times. For the left and right mu rhythm clusters (5 and 6), the central midline cluster (3) and the frontal midline component cluster (2), higher baseline beta amplitude before the response correlated with faster reaction times. Finally for the right posterior alpha (9) and central midline clusters (2), higher gamma band power (40 Hz) correlated with faster reaction times.

Thus, reaction time did not correlate in a single frequency band with a single EEG source. Instead, it correlated with differences in all frequency bands across a variety of EEG sources. An interplay between activities at multiple EEG sources and frequencies appear to influence reaction time, partially explaining the traditional difficulty in its trial-to-trial prediction.