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Classification of Visual Target Detection during Guided Search using EEG Source Localization

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Introduction: It is becoming increasingly common to use experimental paradigms that utilize synchronous eye-tracking and electroencephalographic (EEG) measures to explore the neural processes underlying visual search. In these paradigms, fixation related potentials (FRPs) are used to quantify early and late components of visual processing following the onset of a fixation. However, FRPs often contain a mixture of bottom up (e.g. sensory input from the stimulus) and top down (e.g. saccade planning) processes in addition to electrooculography (EoG) artifacts and unrelated neural activity. In this study we sought to isolate the neural sources of target detection in the presence of eye movements and concurrent task demands.

Material, Methods and Results: In this study we obtained simultaneous eye-movement and EEG measures during a guided visual search task. Participants were asked to identify visual targets (Ts) amongst a grid of distractor stimuli (Ls), while simultaneously performing an auditory N-back task with varying degrees of difficulty. First, we used independent components analysis (ICA) to separate EEG signals into neural and non-neural sources [1]. We then combined these sources, using simplified measure-projection analysis (MPA) [2], to isolate activity in six regions of interest (ROIs): occipital, fusiform, temporal, parietal, cingulate, and frontal cortices.

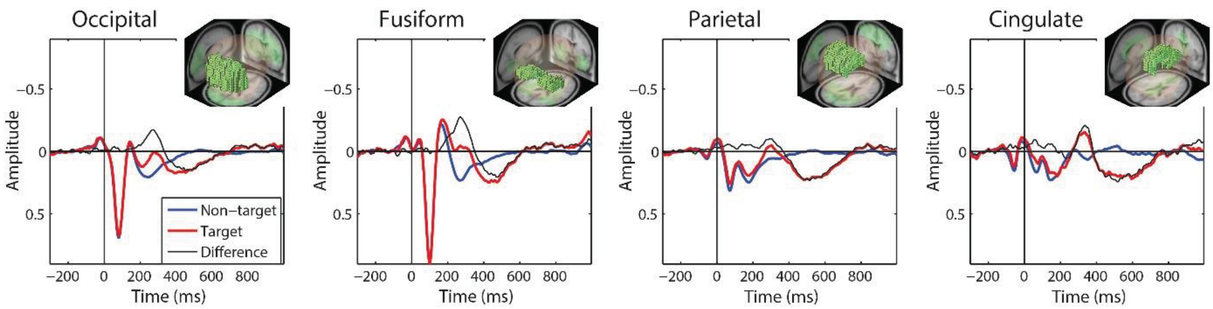

Figure 1. *Grand average neural response from four of the six ROIs. Each figure shows the average of the combined IC activations within the corresponding ROI for all target and non-target fixation. Inset shows the voxels included in each ROI.*

Time-frequency features were calculated from the combined sources on each fixation for all six ROIs. We then employed standard ridge regression with 5-fold cross-validation to construct linear discriminant classifiers for each ROI. Using this approach, we were able to classify target from non-target trials well above chance in all participants. Interestingly, by combining classification scores from each ROI, we were able to achieve classification accuracies significantly higher than those produced from the best ROI for each participant.

Discussion: Thus, our hierarchical approach successfully identified target detection trials across a range of concurrent auditory load conditions. Likewise, this approach was able to elucidate the contributions and time course of task-relevant neural activity from each ROI, in contrast to the majority of previous FRP studies [3], [4]. However, in this experiment saccade distances and fixation times were somewhat controlled. Future work is required to determine if this approach will translate into more real-world scenarios with complex stimuli.

Significance: The accurate, single-trial classification of FRPs would be a significant advance for BCI technologies whose goal is to interpret the neural response to presented stimuli (i.e. reactive BCIs). As visual search is a ubiquitous and natural behavior within humans-computer interaction, the approach described here would provide a less constrained framework for future BCI technologies.

References

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