Neural bases of visual attention and saliency: detecting feature independent perceptual saliency at a single trial level using oddball EEG signals.

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Introduction:
ERP (event related potential) responses to infrequent, task relevant stimuli, often include an attention related component, the P300, occurring independently from target sensory modality. In this study we wanted to investigate the relation between psychophysical detection of visual salient features and their neurophysiological correlates at the event level. For that, we have conducted 2 experimental oddball tasks: Experiment I, designed to test the effects of perceptual saliency on P300 amplitude and latency in colour/luminance and phase offset of low visual features; Experiment 2, to explicitly disentangle luminance from chrominance low-level effects in the P300 modulation by perceptual saliency. We also aimed to investigate whether salient events can be detected at the single trial level.

Methods:
An oddball block protocol was used for both experiments. For each tested visual feature, saliency was experimentally manipulated by having 3 TARGET category levels of perceptual deviance (S+, S++, S+++, in levels of increasing saliency) against a STANDARD featured stimulus (S0). TARGET frequency ratio was of 1:16. EEG signal was recorded from 64 channels, in 10 healthy volunteers, for each task (mean ages=25YO). The experiments took place at IBILI, University of Coimbra.

Results:
Analysis of participants' psychophysical results showed Target detection rates $\geq 90\%$ to highly deviant (salient) categories, $\geq 50\%$ to intermediate, and $\leq 9\%$ to minimum difference (from S0) ones. Grand-average ERPs, time-locked for target category in the PZ electrode, showed a saliency dependence of amplitude. This neurophysiological monotonic effect of saliency was evident both by analysis of P300 amplitude and latency across all visual features. Repeated Measures ANOVA and Wilcoxon Statistics (when applicable) confirmed these peak differences and Spearman Correlations the categorical ordering effect.

Single trial P300 Classification results matched both the ERP and behavioural ones. In fact, it could even detect the presence of deviants even for very low saliency stimuli (>50%). This is remarkable because average ERPs could not detect these events, for which subjects were frequently unaware.

Conclusions: This study shows that one can detect even minimally salient perceptual events at a single trial level. Moreover, the P300 signal is correlated with perceptual saliency levels both from the point of view of amplitude modulation and timing of the response signal.