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Detecting Threat Detection

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Introduction: The understandable importance of detecting threats in real-world situations is evidenced by the prioritization of attention allocation to threat stimuli [1]. The findings presented here represent the first phase of an extensive study investigating the capacity of a neuroadaptive technology to provide an advantage to the human user in threat environments. This phase one study aimed to identify early neural correlates of threat detection, measured via electroencephalography (EEG) in a controlled experimental paradigm, to determine the level of accuracy of threat detection that is achievable on a single trial basis, when compared against non-threat and distractor stimuli.

Material, Methods and Results: A rapid-serial visual presentation (RSVP) task [2], [3] (N = 28) was used to elicit a brain response to stimuli that were either threatening, novel (distractors), or non-threatening (referred to as stimulus type), with stimulus presentation rates of 100-175ms, 200-275ms, and 300-375ms. The EEG data were epoched and standard machine learning methods were used for feature extraction, calibration and testing. For each stimulus type and presentation rate, a different classifier was setup and employed. Classification accuracies were measured via area under the (receiver operating characteristics) curve (AUC). Statistical analyses of the variance between classification accuracies, show that threat stimuli are most accurately separable from non-threat stimuli (Figure 1 (a)) as opposed to distractor (novel) versus non-threat stimuli (Figure 1 (b)), across a range of stimulus categories (i.e., faces, direct threat, and objects and scenes), and for each rate of presentation. Furthermore, the earliest maximal topographical response, observed across broader occipital areas, is elicited in response to direct threat stimuli (Figure 1 (c1), row 1).

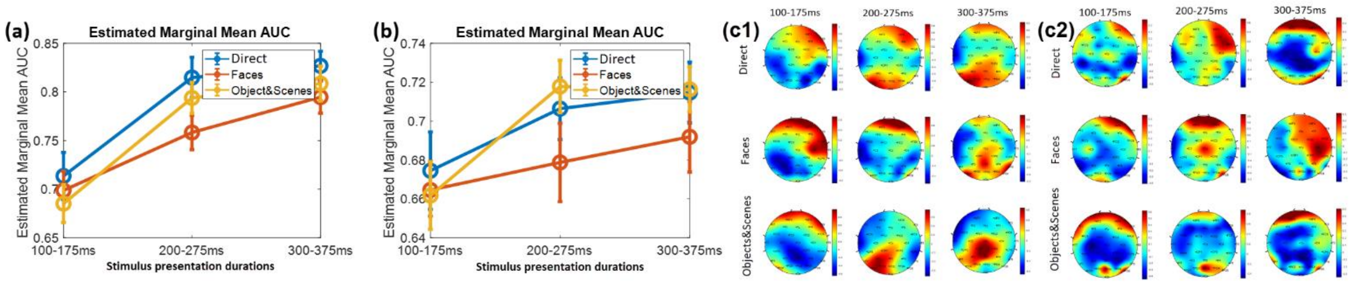

Figure 1. ***RSVP with background and button-press; (a) Threat versus nonthreat and (b) distractor versus nonthreat,*** *presents the estimated marginal means of AUC for classification accuracies – category had 3 levels; direct (blue legend), faces (red legend) and objects&scenes (yellow legend). Presentation rates were 100-175ms, 200-275ms, and 300-375ms.* ***(c1) Threat versus nonthreat and (c2) distractor versus nonthreat,*** *presents a topographical illustration of the cortical activations providing the majority of the information to enhance separability between (c1) threat/ (c2) distractor and non-threat stimuli elicited ERPs, for each category, at each presentation rate.*

Discussion: The findings demonstrate the feasibility of distinguishing threat stimuli from non-threat stimuli, with higher accuracy compared to separating distractor (novel) stimuli from non-threat stimuli, when early event-related potential (ERP) signatures are classified against those for non-threat stimuli.

Significance: These results demonstrate that EEG-based Brain-computer Interface (BCI) technology has the potential to provide a temporal advantage for the detection of threats in dangerous environments.

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