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ERP Features Correlate with Reaction Time in a Posner-Like Covert Attention Task

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Introduction: Spatial hemineglect (unilateral neglect) is a deficit typically developed after right-hemispheric stroke. It affects attention and awareness processes for one side of a patient's space [1]. The feasibility of BCI-based systems to support rehabilitation of cognitive deficits – such as neglect – remains an unexplored field, but BCI-systems making use of overt and covert visual attention to control applications have been explored [3,4,5]. A pilot study with three normally aged control subjects was carried out to study behavior (reaction time upon stimulus presentation) and event-related potential (ERP) responses of the EEG elicited during the execution of a modified Posner task [6]. Testing visual spatial covert attention, this task is a common diagnostic tool in the context of neglect, but trial-to-trial reaction time performance varies strongly. We study the relation between this behavioral performance and brain signals in single trial analysis, using BCI methods.
Material, Methods and Results: Three healthy subjects aged 49, 56 and 51 participated in a single-session EEG study. Fixating the center of the screen, a directional cue indicated to covertly direct their visual attention to one side of the screen at the beginning of each trial. After 2000 ms to 3000 ms, a visual stimulus (gray square) appeared on the cued side of the screen in 90% of the trials, upon which the subject were asked to react by a button press (detection acknowledgement). The remaining 10% were null trials and did not require any action. A sketch of the task can be seen in Figure 1(a). Per subject, 800 trials (20 blocks of 40 trials each) of 64 EEG channels were recorded..
Average ERP responses of channels Cz (solid) and Pz (dashed) are visualized in Fig. 1.b and 1.c. The ERPs of the left plot are windowed relative to stimulus presentation at time t=0 ms. The positivity at 650 ms to 900 ms is stronger for faster responses, as indicated by blue ERP curves and enhanced signed r^2 values in the horizontal bars. ERPs centered relative to the button press at t=0 ms (right plot) reveal a stronger early negativity for fast responses around -100 ms. These two temporal features per channel allowed an average classification accuracy of 0.69, 0.75 and 0.66 (with a chance level of 0.5) for the three subjects. Using only the first feature per channel, the classification values are slightly reduced to 0.63 and 0.70 for subjects 1 and 2, and slightly increased to 0.71 for subject 3.

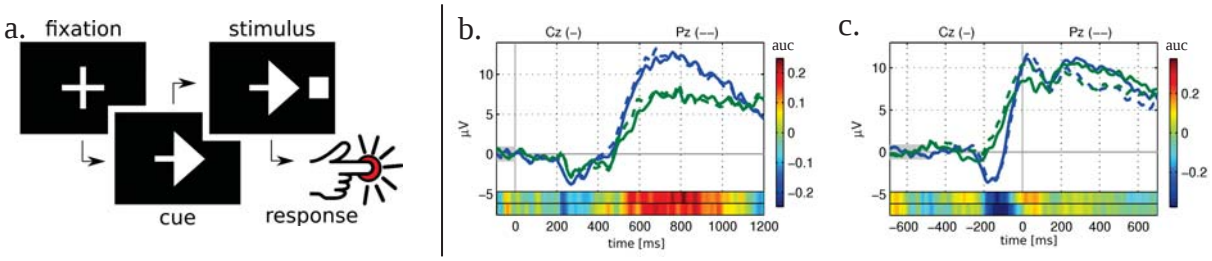

Figure 1. *(a) Sequence of a covert-attention task. (b/c) Averaged ERP responses for two channels. (b) ERPs relative to stimulus presentation (Subject 2) and (c) relative to button press (Subject 1). Blue trials mark fast responses, green slow responses.*

Discussion and Significance: The assessment of a subject's ability to react either rapidly or slowly to a covert stimulus in single trial and based on EEG signals only is challenging. Data of the first three subjects indicate, that an informative neuronal marker for reaction time can be obtained for single trials based on ERP responses. This objective metric may allow to set up novel experimental paradigms for the assessment of patients with neglect, where visuo-spatial attention and visuo-motor interaction shall be studied online without requiring open behavioral responses.

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