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Visual and auditory P300-BCI: influence of daytime on P300 amplitude in patients with ALS

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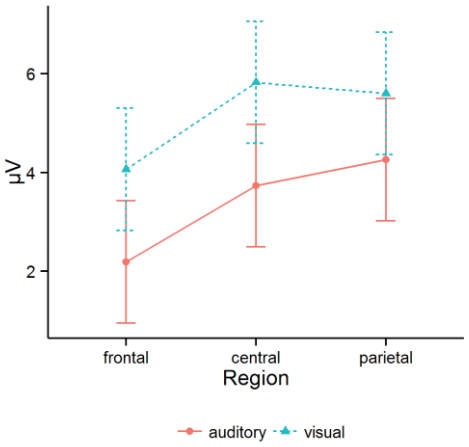
Introduction: The P300 event-related potential is often used as input signal for BCI. In many studies it has been shown that healthy subjects and also patients with neurodegenerative disease can control such a BCI with an accuracy above 90% correct responses [e.g., 1]. Also, BCI relying on auditory stimulation are increasingly investigated, but yield considerably lower information transfer rates [e.g., 2]. Further, patients often present with lower amplitudes. When considering BCI for use in daily life of patients, it is important to know whether the brain signal of interest is stable during the day. Thus, we investigated the visual and auditory P300 amplitude in ALS patients and healthy subjects throughout the day.

Material, Methods and Results: 14 ALS patients (ALS-FRS score: (M = 21.79, SD = 10.53; age: M =67.93, SD = 10.46) and 14 age and sex matched healthy subjects (Ethical Approval obtained). Participants were tested at their home at 10 am, 12 am, 2 pm and 4 pm. EEG was recorded at Fp1, Fp2, F3, Fz, F4, T7, C3, Cz, C4, T8, CP3, CP4, P3, Pz, P4 and Oz. Auditory stimuli were 160 standard (1000 Hz) and 40 deviant (2000 Hz) tones presented in pseudo-random order with the restriction that any two deviant tones were separated by at least one standard tone. Tone duration was 50 ms. Stimulus onset asynchrony (SOA) was 1200 ms with a random latency jitter of ± 0.15 s to avoid habituation to a certain SOA. Visual stimuli were short (50 ms) presentations of the letters "H" (40 times, deviant) and "S" (160 times, standard) in white font (120 pt) on a black background in the centre of a computer monitor. Stimulus onset asynchrony (SOA) was 1.2 ± 0.15 s. Statistical analysis: rANOVA was conducted with time (4), modality (2) and electrode (3, Fz, Cz, Pz) as within and group (2) as between subject factors. P300 amplitude as dependent variable. Pearson correlation between ALS-FRS and P300 amplitude was calculated to assess the effect of disease severity on the P300 amplitude. Preliminary data analysis was published in [3].

We found significant main effects of modality ($F(1,24) = 7.23$, $p = .013$) and region ($F(2,48) = 17.62$, $p < .001$) (Fig. 1). All other tests were not significant, i.e. no effect of time of the day and group! Disease severity did not affect the P300 amplitude of either modality.

Figure 1. *Main effects of amplitude and region. Visual P300 amplitudes were significantly larger than auditory ones, smaller at Fz and equally high at Cz and Pz. Error bars represent 95% confidence intervals.*



Discussion: The most striking result was the lack of differences in amplitude between healthy subjects and patients with ALS; this may have been due to the large variation of diseases severity. As seen before, P300 amplitudes were lower for the auditory than the visual modality. Time of the day did not affect the P300 amplitude. Whether this would transfer to stable P300-BCI performance, which requires more than paying attention to visual and auditory stimulai remains to be investigated.

Significance: These results are encouraging for P300-BCI use in patients with ALS. They imply that patients may use the BCI at any time of the day and that reductions of the P300 amplitude in comparison to healthy subjects may not occur until the later stages of the disease.

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