

Visual and auditory P300-BCI: psychological predictors of performance in healthy subjects

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Introduction: Predictors of BCI performance would be valuable to estimate the likelihood of successful BCI operation. Even more so, if specific predictors could be identified dependent on the input signal for BCI. To date, studies on predictors of P300-BCI performance are sparse. In a sample of severely motor impaired patients (N=11) and another of healthy subjects (N=40) the N2 amplitude during an auditory oddball was highly correlated with later P300 BCI performance of a web browsing task and a visual and auditory P300-BCI spelling task [1,2]. In a sample of healthy participants, a relationship between heart rate variability and BCI performance (visual P300 BCI) was found [3]. Motivation was positively and empathy negatively linked to performance [4,5].

Material, Methods and Results: To further elucidate potential predictors of visual and auditory BCI performance we investigated a sample of 40 healthy BCI novices (21 male, mean age 25.8, SD 8.46 years). Participants' task was to spell 3 times the words "BRAIN POWER" with a visual and an auditory P300 5 x 5 spelling matrix. Visual matrix was standard. In the auditory mode numbers coding rows and columns were presented by a male voice. First the numbers of the rows (1 – 5) and then the numbers of the columns (6 – 10) were presented for selection. On a separate day, participants were presented with a battery of performance, personality, and clinical tests. EEG was recorded with Ag/AgCl electrodes in a 128-channel cap (Easycap GmbH), 67 channels (of these 4 electrooculography) were used during the P300 BCI, sampled at 500 Hz with a band-pass from 0.05 to 200 Hz. **Statistical analysis:** First, in every subgroup of tests a variable selection procedure was performed by correlating the correct response rate of spelling and all independent test variables. Predictors were selected according to the following rule: Variable X gets selected if (I.) it correlates significantly with the CRR and (II.) it is not inter-correlated with other tests of the sub-group.

Average visual and auditory P300 BCI accuracies were $M = 94.5\%$ (SD 14.9) and $M = 64.3\%$ (SD 37.4), respectively. In the visual P300-BCI the ability to learn (non-verbal learning test = NVLT; performance) was positively and emotional stability (B5PO, personality) negatively correlated with performance, but not significant after Bonferroni correction. Logistic regression of the two variables on visual P300 BCI performance explained about 24% of the variance ($R^2 = .24$; $F_{2,36} = 5.74$; $p < .05$). Emotional stability was also negatively correlated with auditory P300-BCI performance, but again not significant after Bonferroni correction. Logistic regression explained 8% of the variance, but was not significant.

Figure 1. Correlation between "sum of the differences of correct minus incorrect YES answers (NVLT=learning) and the visual P300 BCI performance after excluding of two outlier values.

Discussion: Results of only one performance (learning) and one personality (emotional stability) test predicted visual, but not auditory P300-BCI performance. Albeit the P300 is elicited by external stimulation and it is argued that not much learning is involved in controlling a BCI based on event-related potentials, it has been shown that training can improve P300-BCI performance [6]. The contribution of emotional stability was low (results not shown) in the visual and not significant in the auditory P300-BCI.

Significance: Psychological factors as measured with performance, personality, and clinical test seem to play a minor but significant role in P300-BCI performance.

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References

- [1]Halder et al. Prediction of P300 BCI aptitude in severe motor impairment. PLoS One; 8(10):e76148, 2013; [2]Halder et al. Prediction of auditory and visual p300 brain-computer interface aptitude.PLoS One. 8(2):e53513, 2013. [3]Kaufmann et al. Effects of resting heart rate variability on performance in the P300 brain-computer interface. Int J Psychophysiol.; 83(3):336-41, 2012. [4]Kleih et al. Motivation modulates the P300 amplitude during brain-computer interface use. Clin Neurophysiol.;121(7):1023-31, 2010; [5]Kleih SC, Kübler A. Empathy, motivation, and P300 BCI performance. Front Hum Neurosci.;7:642, 2013. [6]Halder et al. Training leads to increased auditory brain-computer interface performance of end-users with motor impairments. Clin Neurophysiol. 2015 [epub ahead of print]

