Oddball (P300) Brain-Computer Interface: The Effect of Depressed Mood and Emotion on Performance

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Introduction

The influence of emotion or mood on BCI performance is still largely unexplored (Kübler & Neumann, 2005) despite the observed emotional states fluctuation and incidence of depression among potential users of BCI, i.e. locked-in patients. A positive correlation between positive mood and sensorimotor rhythm-based BCI performance was observed in a recent study of Amyotrophic Lateral Sclerosis patients (Nijboer et al., 2008), whilst induced emotional states is known to consistently reduce P300 ERP amplitude (Methardin & Pekrun, 2003).

Thus two research questions emerge:
(1) Will P300-based BCI performance be affected by background depressed mood?
(2) Do transient emotional states have an adverse effect in performance?

Participants

Out of 40 healthy participants (F=27, mean age 25.9±7.3 years) who took part in the study, 7 were excluded due to non-compliance to procedure and difficulties in using BCI caused by lethargy and blurred vision. The majority of subjects were psychology students who were given 20 GBP and a course credit where applicable. All participants were screened for psychoactive medication, epilepsy, and traumatic brain injury.

Methods & ERP Acquisition

This is a within-subject study containing 3 experimental conditions. Participants copy-spelled the word BRAINPOWER using a 6x6 letter matrix (Fig. 1) after induced unpleasant, pleasant, or neutral emotion. The induction was done through exposure of 5 IAPS images before each copy-spelled letter. BCI Performance (percentage of correctly copy-spelled letters) were correlated with depressed mood and compared between the three emotion conditions. Ratings of emotion states between conditions and of 30 IAPS images were taken as an induction check.

EEG was recorded using 32-channel BioSemi cap and ActiveTwo ADC. The offline data analysis was carried out with EEGLAB v6.01b. Data were re-referenced offline to the average signal of O1, O2, and 02 and band-filtered between 0.1 and 30 Hz. The grand average data were acquired between -500 and 1000 ms. The pre-stimulus time window acted as baseline and subtracted from the ERP. P300 ERP peak was derived at channels Cz, Pz, and Fz and compared between conditions.

Results

Emotion induction is in the normative direction. Emotion ratings in after each condition was significantly different from baseline for valence F(2,22)=12.6, p<.001 and arousal F(2,22)=62.3, p<.001 (Fig 2a). This was supported by significantly different ratings of IAPS image categories (Fig 2b).

Overall negative correlation between accuracy and depressed mood is approaching significance Spearman’s ρ = -0.29, p = .052.

Emotional state reduces BCI performance in participants with higher depressed mood (HDM) above the median score. One-way ANCOVA revealed significant effect of emotional states on performance in the direction of the hypothesis F(2,22)=3.42, p<.05 but on in the HDM group. There was no difference in success rate between emotional conditions among participants with low depressed mood score or in overall participants data.

Mean amplitude tend to be reduced during affective conditions (ns).

Discussion

Both depressed mood and emotional state appear to have an adverse, albeit minor, effect on BCI performance. Lower performance correlated with higher degree of depressed mood, which is consistent with past findings (Nijboer et al., 2008). Those with depressed mood score above the median value exhibited reduced performance when they were induced to either pleasant or unpleasant emotion. This was significant for participants with higher degree of depressed mood despite the apparent lack of variation in P300 ERP peaks between conditions (only a non-significant tendency for peak reduction during the affective conditions was observed). Further study using more effective method of emotional induction is necessary to clarify the relationship between ERP peak and performance during emotional states. Monitoring users’ mood before copy-spelling session maybe recommended during daily use of BCI.

References


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