The Effect of Emotion on P300 Brain-Computer Interface (BCI) Performance

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Introduction
No studies has investigated the effect of cognitive and emotional states in BCI performance although incidence of emotional problem and depression is increasingly reported among locked-in patients, the primary users of this technological advance. Furthermore, past studies (e.g. Meinhardt & Pekrun, 2003) have shown suppression of P300 event-related potentials (ERP) by emotional experience. This study thus aims to investigate the effect of emotional states and subjective feeling of depression on healthy subjects’ P300 ERP BCI performance. Priming was carried out by using International Affective Picture System (IAPS) of three different affective categories: pleasant, neutral, and unpleasant. The study employed within-subject design and was carried out in three different blocks corresponding to the three affective valence conditions. Peak amplitude and latency of P300 ERP were computed across trials and compared between condition. Subjective feeling of depression i.e. ‘depressed mood’ was assessed using Centre for Epidemiologic Studies Depression Scale (CES-D).

Materials
150 IAPS images, 50 of each category, were used. Images with extreme high and low valence and arousal standard rating were selected. Images were counter-balanced across arousal rating.

C-ES-D consists of twenty items in four-point Likert scale. Example items include ‘I cannot get going’, ‘I felt fearful’, ‘I felt hopeful about the future’ occurring during the past week.

Self-Assessment Manikin (SAM) scale was used to assess subjective rating of mood between experimental blocks and of valence and arousal values of the IAPS images.

P3Speller of BCI2000 was used to present the IAPS images and the 6 x 6 spelling matrix (Farwell & Donchin, 1988) in real time. Figure 1 shows the experimental timeline and the duration of each presentation.

ERP Acquisition
EEG recording was taken using 32-channel Biosemi cap and ActiveTwo ADC. Offline analysis of the EEG data was performed by using EEGLAB version 6.01b. EEG data was re-referenced offline to average potential of channels Cz, Fz, and Pz. EEG recording was taken using 32-channel Biosemi cap and ActiveTwo ADC. Offline analysis of the EEG data was performed by using EEGLAB version 6.01b. EEG data was re-referenced offline to average potential of channels Cz, Fz, and Pz. EEG data was re-referenced offline to average potential of channels Cz, Fz, and Pz.

BCI Performance
BCI performance is defined here as the number of correct letters selected from the letter matrix. The experiment contained one calibration block and three experimental blocks with short breaks in between. Participants were instructed to spell the word BRAIN-POWER in each block and shown five IAPS images prior to each letter. The letter selection was based on the ‘oddball paradigm’. Intensified row or column containing target letters constitute the P300 ERP eliciting stimuli. This occurs twice in a sequence of twelve intensifications (6 rows x 6 columns). Participants self-rated their mood before the first experiment block and after each block henceforth. Participants also rated emotional valence and arousal evoked by thirty randomly selected IAPS images used in the experiment. No feedback was given to the participants with regard to their spelling result to control motivational effects.

Results
Overall differences in valence (F1,53 = 60.72, p < .0001) and arousal (F1,53 = 13.58, p < .0001) mood rating before and after the experimental blocks were found, which corresponded to the participants emotional state ratings when exposed to IAPS images (valence, F1,53 = 326.24, p < .0001; arousal, F1,53 = 73.24, p < .0001, see Figure 2 (a), (b)). Both results showed that the emotional manipulation between conditions were in the normative direction. Grand average ERPs for channel Pz, Cz, and Fz appears to show a trend of slight suppression for amplitudes in affective conditions (See Figure 3). However, no statistically significant differences were found in the peak amplitude and latency of P300 ERP between conditions. Only in channel Fz that a marginal significant difference was seen (F1,53 = 2.49, p = .09). As reflected in the ERP results, no difference was observed in BCI performance between the emotion blocks. Nevertheless, a negative correlation between the subjective rating of depression CES-D scores and total BCI performance was found (r = -.369, p = .016, see Figure 2(c)).

Discussion
Transient emotion state appears to have no effect in BCI performance whilst longer-term depressed mood is related to poor performance. In practice, the former result is desirable for an effective communication device. However, this study failed to replicate suppression of P300 ERP from past findings despite evidence of effective emotional priming. Based on the later result alone, this study cautiously concluded that long-term negative or depressed mood indeed hampers BCI performance. Further study can consider the use of more sophisticated emotional priming method than the current one. Replication of the current result is necessary before stronger conclusion can be drawn.

References


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