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Attention in Complex Environment of Brain Computer Interface

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*Introduction: E*lectroencephalogram (EEG) power is related to human cognitive processing, but in a complex and non-linear way. Attention is one of such fundamental human cognitive processes. EEG power in alpha band is positively related to it, whereas EEG power in theta band simultaneously shows the inverse relation [1]. It has been reported in past studies that if EEG power in lower (8-10Hz) and upper alpha (10-12Hz) supressed than opposite holds true for theta (4-7.5Hz) in attentional process [2]. The main purpose of this study is to explore the hidden nature of attention while involving a video game with high attentional need. This game creates a scenario in which subjects need to pay attention on both of the game and designed task. The attentional changes like handling sequential and random targets in our daily life - one complex environment.

Material and Method: EEG data were collected from 10 right-handed subjects (male; 24.5 years; AD: 500Hz; 32 electrodes; 1-50Hz). A visual match-three puzzle game was used in which stimuli presented randomly 6-8 times in each session (total 6 sessions; played approximately 90 minutes). Subject needed to increase attention for 10s when target appears. The score was given by calculating and quantifying alpha power recorded online from EEG during 10s [3]. For analysis, EEG data from 1s prior as a reference interval and 10s following the onset stimulus were segmented. A power spectrum time series was calculated using the fast Fourier transform (FFT) which was squared and averaged for individual frequency band to obtain a measure of the power spectral density (PSD) from frontal channel (Fz) for each subject [4]. Event related desynchronization (ERD) was also calculated on obtained PSD based on Pfurtscheller method [5]. It is important to note that positive value of ERD indicates power suppression while negative ERD means decrease in power.

Results: Previous studies [1-2] suggested that visual attention is the main factor for suppression of lower and upper alpha band power as well as increase in theta band power. But in the present study, alpha and theta activities as well event related changes in respective power shows yet another pattern of result and complex nature. Our results in ERD (Figure. 1 (a)) and event related spectral perturbation (ERSP) (Figure. 1 (b)) revealed that theta, lower alpha and upper alpha power desynchronized simultaneously during attentional processing.

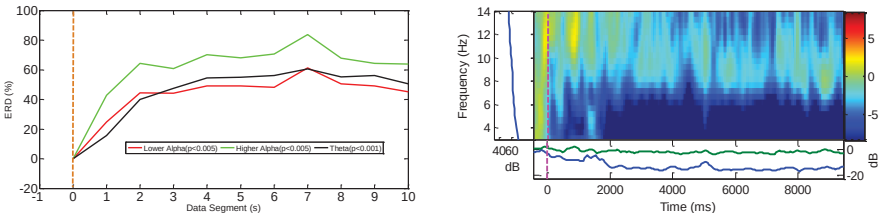

Figure 1 (a) Event related desynchronization (Left); (b) Event related spectral perturbation (Right)

Discussion: The primary result presented in this paper raised a question on current attention brain computer interface (BCI) which is based on alpha and theta inverse relationship. Our result indicated that this inverse relation is not always stable in the complex condition. Therefore, there is a need to design a more precise indicator for monitoring human attention (including resource allocation/attention switching). This finding can be an important step for generalizing and applying for BCI in real-world environment instead of laboratory.

Significance: This work can be applied to improve the development of attention/concentration based BCI.

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