 DOI:10.3217/978-3-85125-260-6-84

EEG Evaluation During Emotional State Elicited by Unpleasant Sounds to be Applied in BCI

A. Atencio[1], A. Benevides[1], T. Bastos[1], A. Ferreira[1]
[1]*Federal University of Espirito Santo, Brazil*

Correspondence: A. Atencio, UFES University, Fernando Ferrari Av. 514, Vitoria-ES, Brazil. E-mail: anibal.atencio@ufes.br

Abstract. EEG-based BCI performance is associated with emotional state like stress or loss of attention of the user. In that sense, this work presents off-line evaluation of the EEG signal in order to inquiry the occurrence of ERD/ERS in the alpha and beta rhythms during the perception of acoustic stimulus. This evaluation was conducted with the purpose of search the correlating EEG signals with user emotional state elicited by unpleasant stimulus. It was found that this kind of stimulus causes a later ERS in temporal scalp regions. Then, aiming BCI applications, the system could have a general class for particular emotional state like stress in which the system switches to a mode that classifies the mental tasks under stress. This approach would improve the BCI reliability, as the number of classes is reduced.

Keywords: BCI, EEG, Unpleasant Sound, Emotional State, ERD/ERS.

1. Introduction

Brain-Computer Interface (BCI) is one of research areas that has been developing relatively fast in the last decades. In this pathway was noticed that the emotional state of the user affects the performance of BCI because induces changes in human biological signals [Picard, 2010]. In the case of scalp electroencephalogram (EEG) signals, for example the loss of attention of the robotic-wheelchair user can cause a decreasing the classification accuracy of EEG-based BCI [Muller et al., 2010]. For this reason, this preliminary work attempts to evaluate EEG signals from BCI user under emotional state elicited by unpleasant sound. This evaluation was conducted with the purpose of search a correlation between EEG signals and user emotional state elicited by unpleasant acoustic stimulus as it is possible that this kind of stimulus increase neural activity in brain cortex. BCI can benefit from adapting their operation to the emotional state of the user. By virtue of its known importance for the paradigm of motor imagination [Pfurtscheller and da Silva, 1999] the goal of the experiments is to verify the occurrence of event-related desynchronization/synchronization (ERD/ERS) in the α (8–12 Hz) and β (14–30 Hz) frequency bands, but during the perception of unpleasant stimulus.

2. Material and Methods

Due to the preliminary aspect of this work one volunteer with no previous history of neurological or psychiatric disorder was stimulated. He has not taken any medication that could have affected the EEG signals and he stated to feel healthy on the day of the experiment. Electrodes placed upon nineteen positions in according to international 10–20 system (see Fig. 1), one-ear reference and one grounding electrode was used. EEG signals were acquired with 200 Hz sampling rate, without artifact rejection and with electrode impedances below 10 KΩ. Common Average Reference spatial filter [McFarland et al., 1997] was applied in order to reduce correlation between channels originated by external noises such as the electric network noise and artifacts of muscular origin.

2.1. Experiment

The experiment consisted of a set of 10 repetitions (epochs), each one lasted 20 s, in which the acoustic stimulus was applied between 5 and 10 s. This stimulus was produced by scraping a sharp knife along the surface of a ridged metal bottle. This sound was ranked with 8.10 ± 1.47 of unpleasantness level [Kumar et al., 2008]. To find out that emotion had been elicited after each repetition, the volunteer filled out SAM self-assessment form [Bradley and Lang, 1994]. In all cases the subject marked most extreme alternatives (arousal close to maximal value and valence close minimal value). These replies would suggest that the volunteer felt himself under negative emotional state like hate or stress during stimulus in accordance with dimensional study of emotional states [Russell and Mehrabian, 1977].

3. Results

ERD/ERS occurs because in the absence of mental activity the individual neurons in a neural mass synchronize with the signal thalamic pacemaker and the mass emits signals in a specific band of frequencies. To inquiry the occurrence

of ERD/ERS in the α and β frequency bands for all channels during the perception of acoustic stimulus was followed the classic method [Pfurtscheller and da Silva, 1999]. In the graphs of Fig. 1 the relative power of the EEG signal in α and β bands for all electrodes is shown.

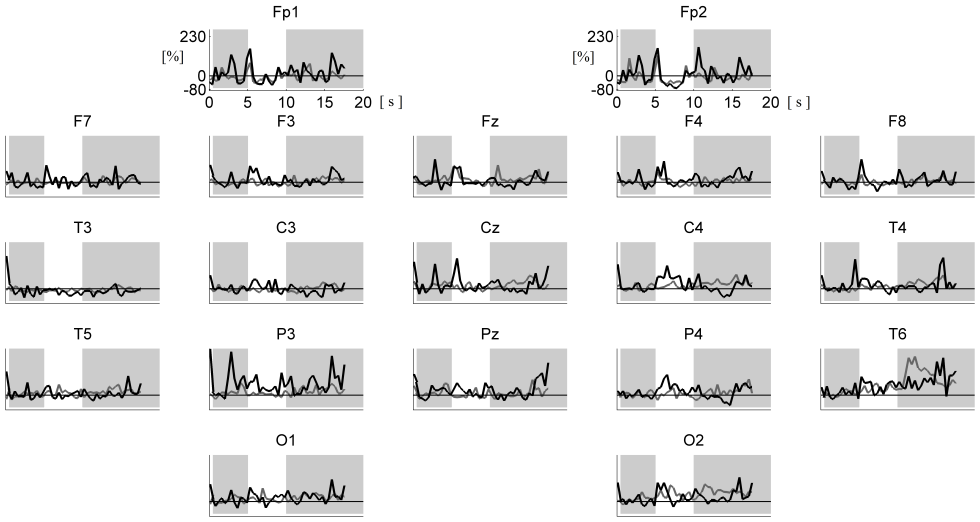

Figure 1: Relative power of α (black) and β (gray) bands. All graphs follow the same scale (-80% to 230% of reference interval). The amplitude and time scales are shown only in $Fp1$ and $Fp2$ channels and omitted in the others. One can notice that a relative decrease in the energy (ERD) during the acoustic stimulus in electrodes $Fp2$ and $F8$. An ERS related to the beginning of the stimulus in electrodes $Fp1$, $Fp2$, $F4$ and $F8$. Also, it worth noting that the energy of β band in electrode $T6$ gradually increases after the stimulus, followed by an slower increase of α band. As the electrode $T6$ is over associative areas of auditory cortex, the high energy plateau measured after the stimulus could be associated to early stages of auditory stress.

4. Discussion

It was observed that unpleasant sound stimulus causes neural activity in frontal and temporal cortex. However by using only ten repetitions we could not observe any significant changes in α and β frequency bands over the frontal electrodes related with neural basis of emotion. The high energy plateau measured over auditory cortex after unpleasant sound could be associated to early stages of auditory stress. Then, a BCI working with n mental tasks would need $2n$ classes to include these tasks under stress emotional state. But, instead of dealing with all mental tasks classes and the new classes under stress, the BCI could have just one more general class for stress in which the system switches to a mode that classifies only the mental tasks under stress. This approach would improve the BCI reliability, as the classification problem is reduced from $2n$ to $n+1$ classes.

Acknowledgments

The authors would like to thank CAPES, FAPES and FINEP (Brazil) for the financial support to this research.

References

Bradley, M. M. and Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *J Behav Therap Exp Psychiatry*, 25(1):49–59.

Kumar, S., Forster, H. M., Bailey, P., and Griffiths, T. D. (2008). Mapping unpleasantness of sounds to their auditory representation. *J Acoust Soc Am*, 124(6):3810–3817.

McFarland, D. J., McCane, L. M., David, S. V., and Wolpaw, J. R. (1997). Spatial filter selection for EEG-based communication. *Electroenceph Clin Neurophysiol*, 103(3):386–394.

Muller, S. M. T., Bastos, T. F., and Sarcinelli, M. (2010). Incremental SSVEP Analysis for BCI Implementation. In *32nd Annual International Conference of the IEEE EMBS*, pages 3333–3336.

Pfurtscheller, G. and da Silva, F. H. L. (1999). Event-related EEG/MEG synchronization and desynchronization: basic principles. *Clin Neurophysiol*, 110:1842–1857.

Picard, R. (2010). Affective computing: from laughter to IEEE. *IEEE Trans Affect Comput*, 1(1):11–17.

Russell, J. A. and Mehrabian, A. (1977). Evidence for a three-factor theory of emotions. *J Res Personal*, 11(3):273–294.