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Novel SSVEP-BCI Setup Evaluation During Emotional State Elicited by Unpleasant Sounds

A. Benevides*, A. Cotrina, T. Bastos
Federal University of Espirito Santo,Vitoria, Brazil

*514, Fernando Ferrari AVE, CT-VI, 101, Vitória-ES, Brazil. E-mail: alessandro.botti@pq.cnpq.br

Introduction: Emotional states can induce changes in biological signals [1]; such as, electroencephalographic signals (EEG); in this sense, the performance of non-invasive BCIs based on EEG could be affected when an emotional state arises. For instance, it was reported the decreasing of the accuracy of the recognition of SSVEP-BCI commands are related to the loss of attention [2]. It causes frustration, fatigue and upset that generates a vicious circle of poor performance of the BCI. In the present work, the performance of a SSVEP-BCI when a subject is unpleasantly stimulated is evaluated. Unlike conventional SSVEP systems that demands gaze movements; the novel SSVEP-BCI setup proposed by [3] is employed. It demands a more meticulous selection condition, in which users must shift their eye focus to select the target stimulus instead of executing muscular movements, due to two stimuli are presented together in the center of his field of view but at different distances.

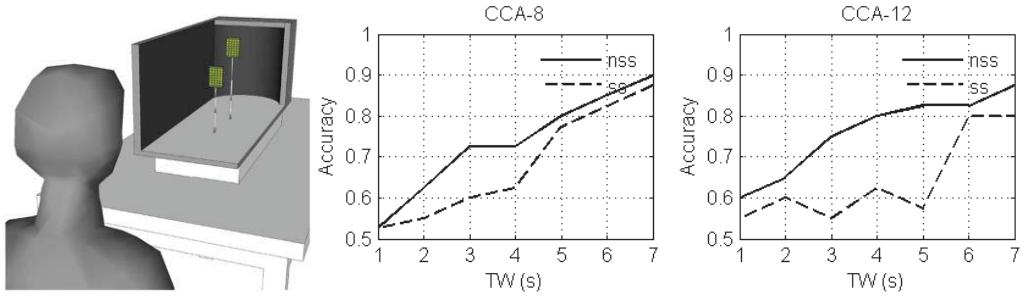

Figure 1. *(Left) The novel SSVEP-BCI setup; Accuracy for TW from 1 to 7s for CCA-8 (middle) and CCA-12 (Right) detection methods. Solid line: Accuracy during **nss** experiments. Dashed line: Accuracy during **ss** experiments.*

Material and Methods: Preliminary experiments were conducted with a healthy male subject. Sixty trials of 9s (2s of rest and 7s of task) were recorded wherein half of them had sound stimulation. Five unpleasantness sounds with approximately 70-80 dB of sound pressure level that were reported in [4] were randomly presented during the selection tasks. The novel setup consists of two 5×7 green LED arranges (13×18 mm) with frequencies of 5.6 and 6.4 Hz, and placed at 30 and 50 cm from the user (Fig. 1 - left). EEG signals were acquired from channels P3, P1, Pz, P2, P4, PO7, PO3, POz, PO4, PO8, O1, Oz, and O2 at sampling rate of 200 Hz, with biauricular reference and grounded at AFz. Canonical Correlation analysis (CCA) was performed for SSVEP detection.

Results: Middle and rightest insets of Fig. 1 show the accuracy of CCA-8 and CCA-12 for time window (TW) from 1s to 7s, respectively. Suffixes 8 and 12 indicate the number of channels. As expected, the accuracy without unpleasant sound stimulation (nss) is higher than with sound stimulation (ss), in both cases for all TW.

Discussion: Although only one subject was considered in this study, results of sixty trials and seven TW indicates that the BCI performance is affected by unpleasant sounds. Hence, due to the focus shift is a more meticulous task, the decreasing of the performance can be attributed not only to the BCI but the loss of the will of the user.

Significance: Currently, hybrid-BCIs that detect emotional states and adapt the BCIs operation are being proposed. However, the user contribution to the reduction of BCI performance (due to their unwillingness) is rarely considered. Finally, after validate these preliminary results with a statistically valid number of users and experiments, a mechanism to avoid or overcome user unwillingness could be added to BCI systems.

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