

Towards a BCI Based on Vergence Eye Movements

A. Cotrina^{1*}, A. Benevides¹, T. Bastos¹, C. E. Pereira²

¹Federal University of Espirito Santo, Vitoria, Brazil; ²Federal University of Rio grande do Sul, Porto Alegre, Brazil

*Av Fernando Ferrari 514, Vitoria, Brazil. E-mail: acotrin@gmail.com

Introduction: Vergence eye movements occur when each eye moves simultaneously in direction opposite that of the other eye, ensuring that the image of an attended object is projected in the fovea of both eyes [1]. Binocular disparity and depth of field play important roles in 3D perception [2]. In the present work, a novel SSVEP-BCI stimulation setup is proposed, which allows users to select the target stimulus by vergence. With this aim, two stimuli are placed collinearly with the midpoint between the eyes (Fig 1a) and properly separated so that if any stimulus is attended, the other one is perceived duplicated and defocused due to the binocular disparity and depth perception, respectively (Fig. 1b). Hence, the elicitation of SSVEP by the attended stimulus is evaluated.

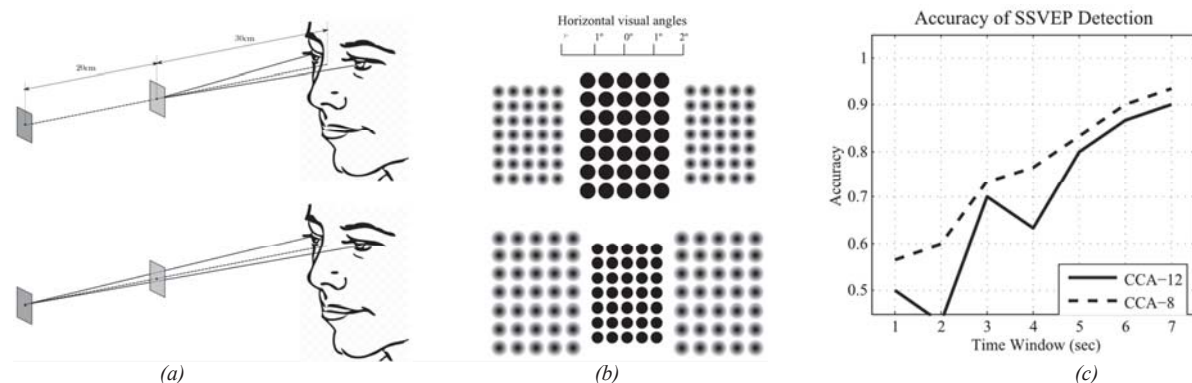


Figure 1. (a) Placement of two LED stimuli when the nearest and farthest stimuli are being attended. (b) Subjective perception of stimuli when the nearest one (top) or farthest one (bottom) is being attended. (c) Accuracy rate of SSVEP pattern detection.

Material, Methods and Results: Two stimuli based on 7x5 green LED arrangements of dimensions 18x13mm² and flickering at 5.6 and 6.4 Hz were used. One of them was placed at 30cm from the center point of the user's eyes and a second stimulus was placed 20 cm behind the first one (Figure 1a). A preliminary experiment was conducted with a healthy subject. EEG signals were recorded from passive electrodes at locations P1, P2, P3, P4, Pz, PO3, PO4, PO7, PO8, POz, O1, O2, and Oz, with bi-auricular reference, grounded at AFz and with a sampling frequency of 200 Hz. Signals were re-referenced at Pz and Canonical Correlation Analysis with eight (CCA-8) and twelve (CCA-12) electrodes were used to evaluate the SSVEP pattern elicited by the attended stimulus. Signals of sixty trials of 9 s were recorded (2 s of rest and 7 s of task). Subject was asked to attend one of them stimulus randomly. Accuracy rates for different time windows (TW) are shown in Fig. 1c. SSVEP pattern was clearly elicited attaining accuracy rates greater than 0.8 for TW > 4 s. The highest accuracy was 0.93 with CCA-8 for TW = 7 s.

Discussion: Results indicate the attended stimulus can elicit a distinguishable SSVEP pattern with high accuracy rate. This is because the amplitude and latency of visual evoked responses are affected by defocusing [3]. Thus, a focused stimulus is able to elicit a SSVEP pattern even if non-focused stimulus is present in the field of view [4]. In addition, Conjugate (horizontal or vertical) eye movements are not required, even if the user is able to do so, to select the target stimulus because both stimuli are placed in same imaginary line (Fig. 1a).

Significance: The stimulation setup here proposed could be evaluated by patients with motor impairment by virtue of the convergence together with the accommodation of the lens (which brings the object into focus) and pupillary constriction (which increases the depth of field and sharpens the image on the retina) are reflexive movements that responses elicited by interest in a near object [1].

Acknowledgements: Authors wish to thank the CAPES agency by PROCAD founding.

References

- [1] Purves D, Augustine GJ, Fitzpatrick D, Katz LC, LaMantia A, McNamara JO, Williams SM. Neuroscience, Fourth Edition. Sinauer Associates, Massachusetts, 2008.
- [2] Ebenholtz SM. Oculomotor Systems and Perception. Cambridge University Press, 2001.
- [3] Sokol S, Moskowitz A. Effect of retinal blur on the peak latency of the pattern evoked potential. Vision Research, 21(8):1279-86, 1981.
- [4] Cotrina A, Benevides A, Castillo J, Ferreira A, Benevides A, Rojas D, Bastos T. A SSVEP-BCI based on Depth-of-Field. IEEE Transactions of Neural System Rehabilitation Systems. (Submitted)