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Transparent c-VEP-based passive BCI to probe spatial attention

P. Cimarosto[1*], K. Cabrera Castillos[1], S. Velut[1,2], R. N. Roy[1], F. Dehais [1]

[1]*Fédération ENAC ISAE-SUPAERO ONERA, Université de Toulouse, France;*

[2]*A&O - LISN - Université Paris-Saclay, 1 rue René Thom, 91190 Gif-sur-Yvette - France*

*10, Avenue Marc Pélegrin, 31055, Toulouse, France. E-mail: Pietro.cimarosto@isae-supaero.fr

Introduction: Code Visually Evoked Potentials (c-VEP) have garnered significant attention within the Brain-Computer Interface (BCI) community. Traditionally employed for enabling hands-free interactions in reactive BCI systems, c-VEP present a novel application within passive BCI systems, aimed at spatial attention tagging. Our team has innovatively developed transparent textured flickers to seamlessly integrate attention tagging without causing distraction or eye strain, achieved by carefully adjusting contrast and intensity to remain at the threshold of conscious perception [1][2].

Material, Methods and Results: In this study, we aim to extend the current paradigm to more ecologically valid settings, using the Multi-Attribute Task Battery (MATB), which includes three subtasks: Monitoring (responding to visual alerts), Tracking (maintaining a crosshair in the center), and Communications (reading back radio communications) – see Fig. 1a. Three stimuli were presented imperceptibly across these subtasks. These stimuli, flashed aperiodically with unique binary codes (sequences of 1 – on, and 0 – off), are designed to minimize correlation. By reconstructing the observed c-VEP codes in real time, we achieved predictions of participants' spatial attention targets at ~30 Hz. We tested our approach on 10 participants using the LiveAmp EEG system, alongside an eye tracker as ground truth for spatial attention. The session included an 80s calibration followed by 300s of passive supervision of cued MATB subtasks. The results are displayed on Fig. 1b.
Conclusion: The results demonstrate that our system successfully generated continuous predictions that were consistent with the output of the eye tracker, validating the effectiveness of our pBCI with its short calibration time and nearly invisible flickers. Future research will focus on the real-time integration of EEG and eye-tracking data streams to provide a more comprehensive understanding of the user's state. By leveraging neural responses as indicators of cognitive processing depth, this approach aims to enable cooperative and synergistic use of neural information, enhancing human-computer interaction.

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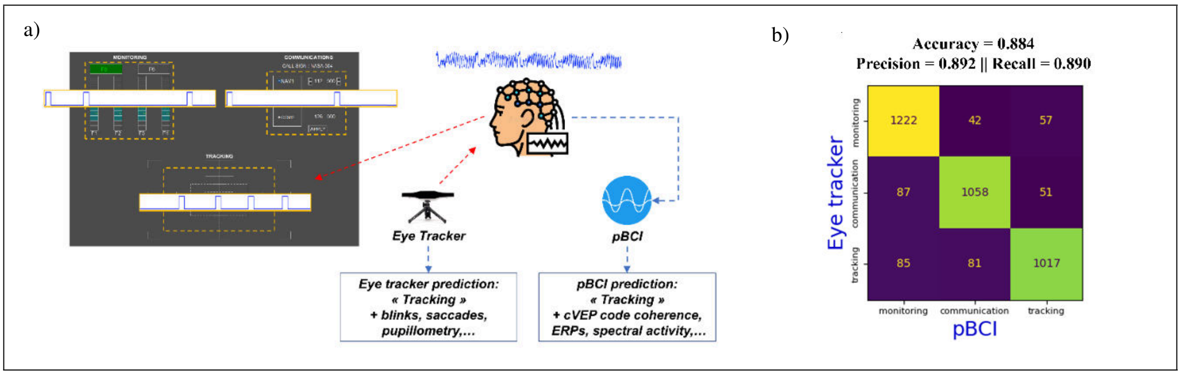

Figure 1: a) *Implementation of the c-VEP based BCI and the eye tracking system to tag spatial attention; b) Confusion matrix of pBCI predictions and Eye Tracker predictions and related Accuracy, Precision and Recall;*

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