COMPARATIVE ANALYSIS OF P300 DETECTION ACCURACY IN TRADITIONAL AND HEAD MOUNTED DISPLAY ENVIRONMENTS

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INTRODUCTION

The Rapid Serial Visual Presentation (RSVP) is an approach for Brain Computer Interfacing in which a series of images are displayed at high speed [1]. Participants are asked to differentiate between a set of target images and a set of standard images, where the P300 event-related potential (ERP) is evoked by a target image but not by non-target images [2].

Despite the extensive use of RSVP paradigms for P300 elicitation, most studies rely on traditional computer monitor displays. This experimental setup offers a consistent and familiar visual environment, reducing distractions and delivering accurate data for P300 detection. However, real-world applications of BCIs frequently go beyond the boundaries of a standard laboratory setting, necessitating systems that work in dynamic and engaging environments. For example, BCIs designed for immersive gaming or other settings that mimic real-world situations.

This study seeks to close this gap by comparing the effects of two display modalities—traditional monitor vs. head-mounted display (HMD)—on P300 prediction accuracy. We aim to know if an immersive, HMD-based environment influences the reliability of ERP detection and if it can deliver equivalent or better performance than regular settings. This study will assist those designing future BCIs for real-world applications, where they will be deployed in dynamic, engaging, and interactive environments.

MATERIALS AND METHODS

This study uses the two datasets of 'AMBER: Advancing Multimodal BCIs for Enhanced Robustness—A Dataset for Naturalistic Settings' [3], collected at Dublin City University, Ireland. An Ethical approval (DCUREC/ 2021/175) was obtained to record Data-1 (with monitor screen) and Data-2 (with head-mounted display) with ten healthy participants aged 20–35 in each variant. A 32 channel ANT-Neuro eego sports system, with CPz as the reference was used to record EEG data at 1000 Hz. Each participant completed four 90-second RSVP blocks, containing 360 images (324 non-targets, 36 targets) per block.

A Bayesian Ridge Regressor [4] was used for single-trial P300 detection [5, 6].

RESULTS

Considering the class imbalance of the data, ROC-AUC was used to assess model performance and the results for both datasets are given in the Figure 1.

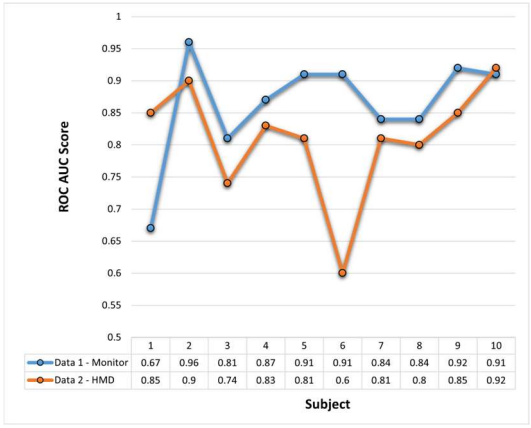

Figure 1 Comparison of ROC AUC scores for each subject for monitor vs HMD RSVP display.

DISCUSSION

The ROC AUC results obtained in monitor-based setting are high, with an average of 0.864 across 10 subjects. This indicates that P300 prediction using a monitor setup is more performant.

The head-mounted display, while slightly less effective in terms of AUC scores (average of 0.811), demonstrates that the HMD environments can still provide valuable data for P300-based studies. However, the lower scores suggest increased mental fatigue or a greater cognitive load impacting the subjects' responses.

CONCLUSION

Results show that a traditional monitor remains a reliable choice for P300 detection. Although the head-mounted display's performance is slightly lower, it indicates the feasibility of using immersive environments for P300 studies, possibly targeting applications that benefit from realistic and engaging scenarios.

Researchers designing future experiments should take these performance differences into account when designing their experiments.s

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