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# Brain-Computer Gaming Control through Imagined Speech Commands in Single-player

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*Introduction:* Brain-Computer Interface (BCI) controls are traditionally managed by motor imagery, acting as a proxy for directional commands. Using imagined speech (IS), the user's intent directly conveys directions which makes the experience more engaging while closely mirroring real-life situations [1]. In this study, we developed two modes of a BCI controlled, calibration and singleplayer. We evaluated the user's subjective experience and examined whether these two modes shared similarities through a learning model. This approach integrates strategy, dynamic lighting, and immersive sounds, effectively mimicking the environments where a BCI would typically be utilized.

*Material, Methods, and Results:* Twenty-six healthy volunteers (19 males, 7 females, aged 20.1 ± 1.09, range 18–24) participated in the experiment. All were right-handed native Spanish speakers from Mexico with no speech or language production issues and no clinically diagnosed attention deficit disorders or physical impairments. EEG data was collected using an 8-channel EEG Unicorn Hybrid Black headset (250Hz sampling rate) with electrodes placed at FC3, C3, F5, FC5, C5, F7, FT7, and T7.
Participants completed demographic questionnaires. They then engaged with a non-invasive, endogenous, synchronous, active, and discrete BCI in the form of a maze-like video game. Post-game, they answered a Flow State Questionnaire (FSQ) and Sense of Agency Scale (SoAS).
The calibration mode followed automatic movements to train a classifier, used in the singleplayer mode to predict their imagined speech commands in real time. Misclassifications provided additional samples for the classifier, which biased the data set in one direction, see Fig. 1.
The FSQ presented a score greater than 3 on a scale of 1 to 5. The lowest Sense of Positive Agency was 50% and the highest Sense of Negative Agency was 67%.
Regarding the EEG data, classifying the directions was underwhelming, with accuracies no better than chance level (25%). However, classification between the two game modes using EEGconformer [2] achieved an accuracy of 84%, a minimum accuracy of 48%, and a maximum accuracy of 100%.

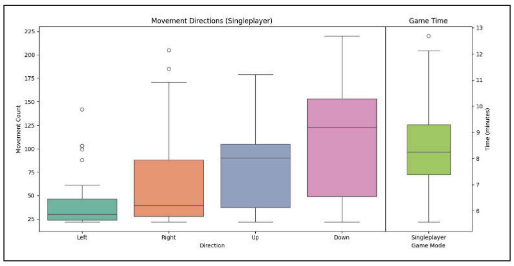


Figure 1: *"Boxplot displaying the total commands per direction in singleplayer mode and the time taken to execute them. There were more trials for directions where the classifier had the highest error rates.*

*Conclusion:* Despite the biased real-time classifier, the overall public response showed a positive Sense of Agency and Flow State. Interestingly, even though the calibration and single-player EEG recordings were conducted within the same hour-long session, the classifier could distinguish them. This observation suggests that a dedicated calibration section might not be reliable for the game, as it may not capture the challenge of actual gameplay. Therefore, a dynamic approach where the game learns and adapts in real-time is recommended. Last, an additional contribution of this work is an IS-based dataset recorded during the two game modes.

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*References:*

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