MSc in Computational Cognitive Neuroscience

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Investigating the Effect of Emotional Stimuli on Visual Imagery Performance in EEG-Based BCI System

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1. Background

Electroencephalography (EEG)-based Brain-Computer Interface (BCI) systems have emerged as a groundbreaking technology, enabling direct communication between the brain and external devices[1]. Emotional stimuli can modulate cognitive processes, including attention, memory, and decision-making[2]. Visual imagery, a mental process that involves creating or manipulating images in one's mind, has been widely studied in the context of BCIs, as it can generate distinct EEG patterns that can be used for control. By examining the influence of emotional stimuli on VI performance, this study seeks to improve the understanding of the interplay between emotions and cognitive processes in BCI systems, which could potentially lead to more effective and adaptive BCI applications.

2. Objective

Aim: Identify specific electrophysiological markers that are affected by emotions in VI-based BCI systems, with the aim of improving their efficiency and reliability.

Hypothesis: There is a relationship between emotional states and cognitive flexibility, where emotional stimuli can influence flexibility and response conflict. Positive emotions may promote flexibility and reduce response conflict, while negative emotions may also have an impact in the opposite direction.

3. Methods

Experiment Design: Within-subject design with six blocks of trials (Fig 1), each containing emotional stimuli (positive, negative, neutral) and VI tasks (Fig 2).

Fig. 1 VI Paradigm

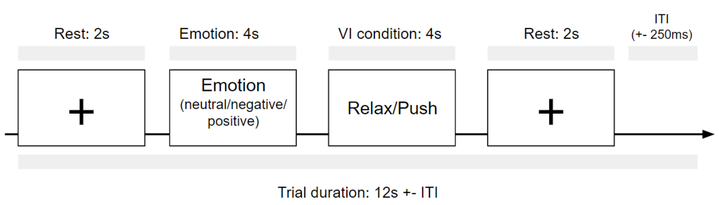


Fig. 2 Screenshots of Push and Relax

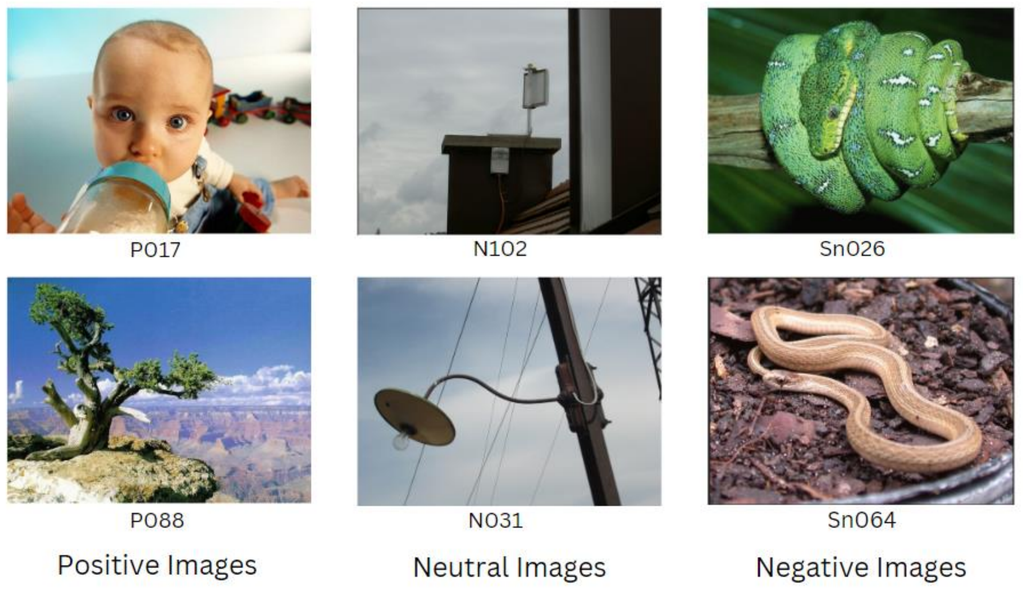
Participants: 30 Healthy individuals, with equal gender distribution, between 18-45, having no neurological disorders or prior experience with VI-based BCI systems. Exclusion criteria include individuals with a known phobia of snakes or spiders

Methods (cont.)

Experimental Setup: EEG system with 64 channels BioSemi ActiveTwo 512 Hz.

Materials and Stimuli: GAPED[3] database images (Fig 3) rated for valence, arousal, and ethical and legal norms.

Fig 3.



4. Pre-processing

- **Pre-processing**: Cleaning the raw EEG data to remove artifacts and noise by applying low and high pass filters.
- **Feature Extraction**: Relevant features are extracted from the pre-processed EEG data. This can include time-domain features, frequency-domain features, time-frequency features, or statistical features.
- **Data Analysis**: Methods like cluster-based non-parametric analysis to identify sensor spectral temporal pairs where a significant difference exists between conditions.

5. Future Steps

- **Next phase**: Implementing ML models for classifying different emotional conditions. Utilizing SVM, KNN, or ANN to learn and recognize patterns.
- **Performance evaluation**: Assessing model performance using accuracy, precision, recall, and F1-score metrics.
- **Cross-validation**: Employing cross-validation techniques to ensure generalizability and evaluate the classification system's robustness.

[1] Wolpaw, J. R., & Wolpaw, E. W. (2012). Brain-Computer interfaces: Principles and practice. Oxford University Press.
[2] Achar, C., So, J., Agrawal, N., & Duhachek, A. (2016). What we feel and why we buy: The influence of emotions on consumer decision-making. Current Opinion in Psychology, 10, 166–170. https://doi.org/10.1016/j.copsyc.2016.01.009
[3] Dan-Glauser, E. S., & Scherer, K. R. (2011). The Geneva affective picture database (GAPED): a new 730-picture database focusing on valence and normative significance. Behavior research methods, 43, 468-477.

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