BCI-based Game control to Boost Focus and Attention in Students

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- Research Interests
  - Brain-Computer Interface
  - Machine Learning
  - Signal Processing

Introduction

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Diminished Focus and Attention among college students affect their academic performance and well-being

The main **purpose** of this study is to use a non-invasive EEG-based Brain-Computer Interface (BCI) system to control games that are designed to improve focus and attention

BCI is a technology that enables communication between the human brain and computer-based external devices [4][5]

Brain-Computer Interface (BCI)

BCI-based training sessions have been used to enhance children's engagement in reading [9]

Online EEG-based neurofeedback games have been used to enhance attention and memory [1][2]

P300-based Speller is the most commonly used BCI system [6]

P300-based Speller

P300-based Speller has been used to treat attention-deficit/hyperactive disorder in children [7]

Authors in [3] used a P300-based BCI interface to improve attention

For this study, the **P300-based Speller** game was utilized as a training tool to help enhance the cognitive abilities of students

Goal of the study

- Explore the effect of the P300-based Speller game with and without feedback on enhancing the focus and attention of the students

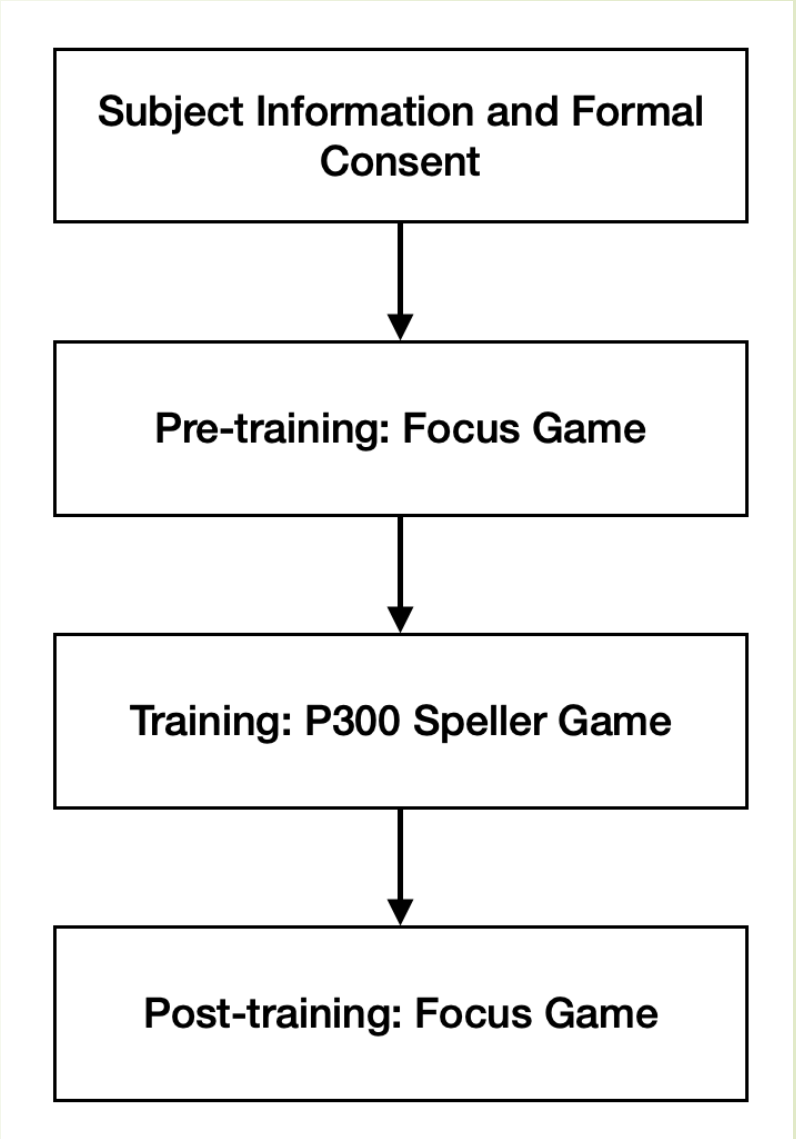
Materials and Methods

Subject Information

- The study was approved by the university's IRB
- 7 subjects from the Department of Computer Science volunteered for the study
  - One of the subjects reported as neurodivergent thus was not considered for further study

Procedure

- All three tasks were completed in a single session
- During all the tasks, subjects sat in a comfortable chair approximately 75 cm from the monitor



EEG Data Collection

- EEG data was collected using g.Nautlius Multipurpose 16-channel EEG Cap
- Data was recorded from 16 channels
  - FP1, FP2, F3, FZ,F4, T7, C3, CZ, C4, T8, P3, PZ, P4, PO7, PO8, and OZ
- All the electrodes were referenced to the right ear
- The data was amplified, band pass filtered from 0.5 – 500 Hz, and digitized t 1200 Hz

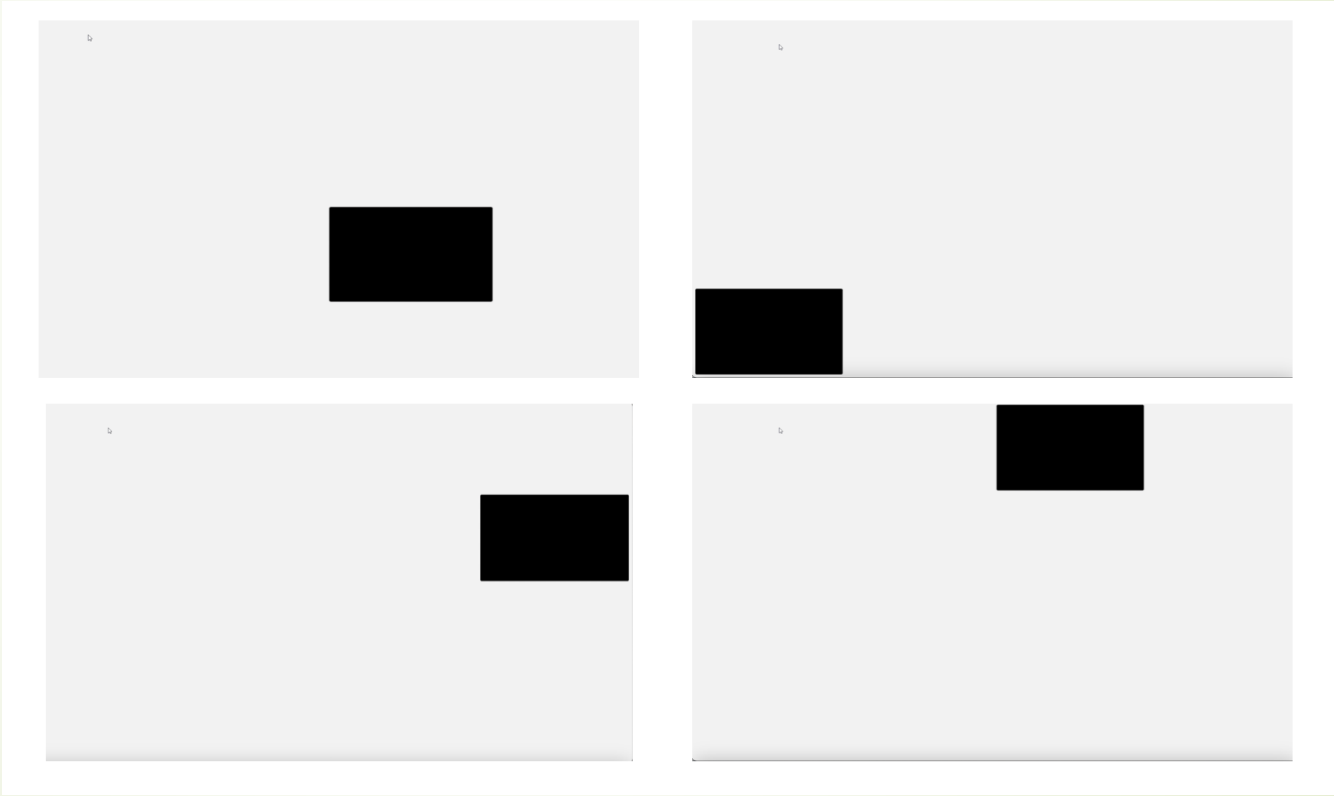
Pre-Training Focus Game

- Focus game lasted for 5 minutes
- Moving target appeared 50 times in total

Training: P300-based Speller

- Each session of the P300-based Speller game consisted of 4 runs
- Each run was composed of a 5-letter word
- The rows and columns intensified for 100 ms with 25 ms between intensifications
- There was a gap of 2 seconds between each run

Post-Training Focus Game



Preliminary Results

EEG Analysis

- To access the quality of the recorded EEG data
  - Offline P300-based Speller accuracy was computed
- For each subject
  - All the data was LPF to 20 Hz and decimated to 240 Hz
  - An optimal classifier based on the Random Forest algorithm was trained
  - For each channel, 800 ms of the data segment was extracted following each flash
  - Feature vector corresponding to each stimulus was created by concatenating the extracted data by segments
  - 80% of the data was used for training and validation

Training and Testing Classification Accuracies

Subject	Training Accuracy (%)	Testing Accuracy (%)
A	99.9	99.7
B	99.5	99.4
C	99.6	99.6
D	99.6	99.8
E	99.4	99.4
F	99.8	99.9

Improvement in Focus Game Score

- **The p-value obtained was 0.03049**

Subject	Improvement in Score (%)
A	20
B	2
C	2
D	10
E	4
F	7

Conclusion and Future Work

Conclusion and Future Work

- In this study, subjects were not given any feedback while they were training via the P300-based Speller Game
- It is being anticipated that giving subjects neurofeedback while they are training, will have a very strong positive impact on the overall performance
- The authors plan to implement neurofeedback as a part of the future work.

Conclusion and Future Work

- The EEG data recorded during the focus game was not analyzed and thus is another potential candidate for future work.
- With the analysis of this data, we may be able to find out what changes in brain activity lead to such improvements.

Conclusion and Future Work

- This study has the potential to make a significant contribution to the field of education and technology by providing insights into how the P300-based Speller Game can be effectively used to enhance students' focus and attention.
- The results of this study could lead to the development of new educational tools and methods that utilize BCI technology to improve student engagement and performance in the classroom.
- Ultimately, our goal is to make learning a more interactive and effective experience for students.

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Questions

Thank You