Brain Computer Interface: Evaluating the Effectiveness of the BCI2000 P300 Speller

Kimberly The, Patricia L. Davies, William J. Gavin
Colorado State University

Introduction

Brain Computer Interface (BCI) measures CNS activity and converts it into alternative output that replaces, restores, enhances, supplements, or improves natural CNS output and thereby changes the ongoing interactions between the CNS and its external or internal environment. New mode of communication for subjects with diseases and injuries resulting in the loss of voluntary muscle control (amyotrophic lateral sclerosis - ALS, multiple sclerosis, high-level spinal cord injuries or severe cerebral palsy). If all voluntary muscle control is lost, a locked-in syndrome results in which a person is unable to communicate with the outside world.

Purpose

Determine the effectiveness of the P300 speller module of the BCI2000 by designing a paradigm to measure the rate and accuracy of word production.

Determine the effect of training on rate and accuracy of word production using the BCI2000 P300 speller.

BCI2000 System: P300 Speller

The BCI2000 system software is available to the public online for BCI research and is compatible with a wide variety of EEG operating systems.

The P300 speller uses the brain activity of the P300 component, a measure of neural activity 300ms post-stimulus onset, thought to reflect cognitive processing and attention to the task at hand.

BCI2000 General Parts
1. P300 Speller
2. Screen to monitor raw incoming EEG signals
3. Screen that displays averaged event related potentials
4. Configuration settings
5. Application Logs to display commands

EEG measures electrical potentials of the brain at the surface of the scalp that is possible because of the columnar organization of neurons in the cerebral cortex.

Study Design

Participants
10-15 neurotypical adults (ages >18)

Procedure
The P300 speller contains a grid with rows and columns that flash at rapid rates. We will ask the participants to count the number of times a target letter flashes until the target letter has been selected. Participants will be asked to make 5 visits to the lab:
1. Initial EEG recording after practice (same difficulty for all participants)
2. Practice (Short words + short sentences)
3. Practice (Medium sized words + Medium sized sentences)
4. Practice (Long words + long complex sentences)
5. Final EEG recording after practice (same difficulty for single letters, words, and sentences)

Electrophysiological Measurements

Biosemi System
33 scalp sites, 2 bipolar eye electrodes
Recorded at 1024 Hz sample rate
Re-referenced offline to bilateral ear lobe electrodes
10 to 200 Hz band pass (24 dB/ octave)
Segmented -100 to 600ms
EOG artifact rejection (+/- 100 µV)
Baseline corrected from -200 to 0ms

BCI2000 System
Accuracy measurements

Discussion

This study is designed to test the BCI2000 for implementation in a clinical setting. Therefore the study will contain real words and sentences rather than nonsense ones.

To encourage greater attention to the stimulus in hopes of eliciting greater and more clear P300's, we can change the settings on the P300 Speller to fade the non-flashing characters to increase contrast between target and non-target letters.

By asking participants to count the number of times the target letter flashes, it may increase attention and elicit greater P300's.

Conclusions

Results from the BCI2000 will be used as a basis of comparison for algorithms that may be developed in the future.

With the data collected from this study we can develop more effective techniques to train clients on BCI2000 system.

This study will advance our knowledge in the application of BCI and allow us to begin to translate these results into the home of persons with severe motor impairments.

References

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