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

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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.[1]
- 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.[2]

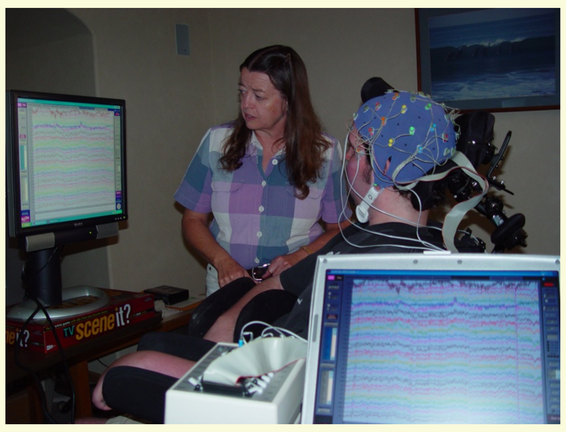

Figure 1:BCI technology can enhance quality of life for people with motor disabilities. Dr. Patti Davies of the Brainwaves Research Lab collecting EEG data from a client with a motor impairment.

- Need to develop more efficient and user-friendly BCI systems through the use of noninvasive electroencephalography (EEG).
- 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.

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.

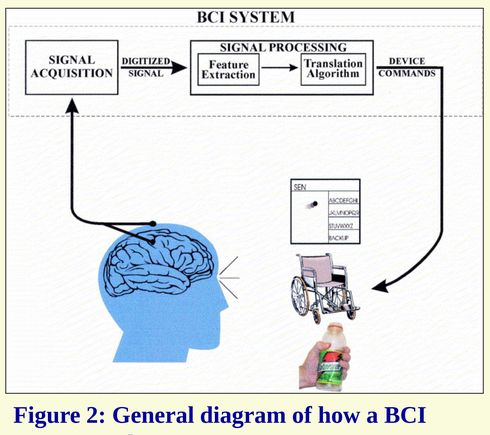

Figure 2: General diagram of how a BCI system works.

BCI2000 System: P300 Speller

- The BCI2000 system is software that is available to the public online for BCI research and is compatible with a wide variety of EEG operating systems.
- This study will utilize the BCI2000 in combination with the Biosemi EEG system.
- 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

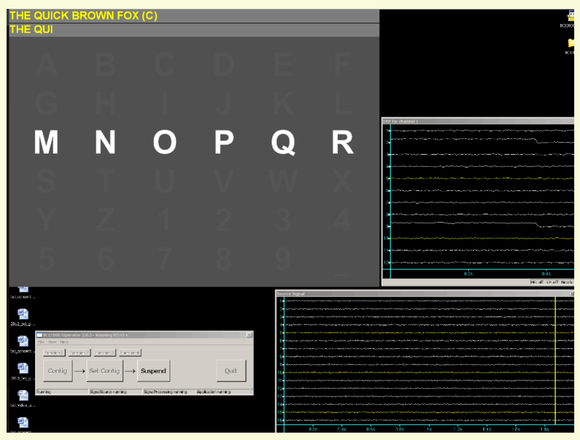

Figure 3: Components of the BCI2000 P300 speller

- The P300 speller contains a grid with rows and columns that flash at rapid rates.
- The selected target letter or character will evoke the largest P300 component in comparison to other characters on the screen.
- The BCI2000 system determines the desired character in real time by analyzing the P300 responses.
- The participants will continue until they have spelled a specific word.

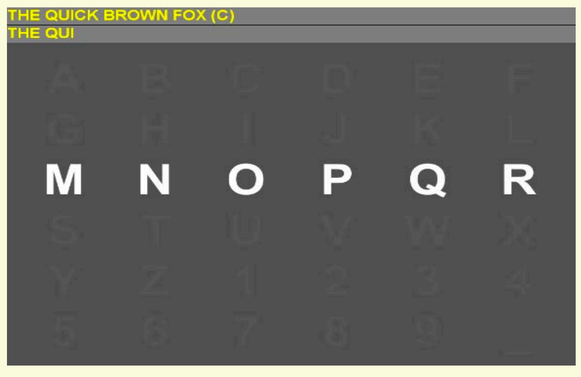

Figure 4: P300 Speller in Action

- BCI2000 contains four modules[3]
  1. Source (Data Acquisition and Storage)
  2. Signal Processing
  3. User Application
  4. Operator Interface

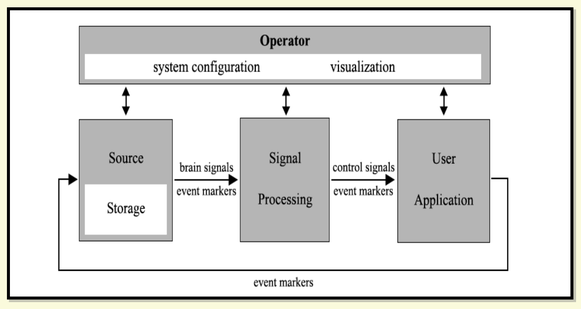

Figure 5: BCI2000 Operating System[3] (pg 39)

- *The Source module* acts as an input and receives neural signals from the brain.[3]
- The *Signal processing module* transforms the brain signals into an output signal.[3]
- The *User application module* uses the output signal to drive the specific BCI program in use. The user application will be the P300 speller.[3]
- There is feedback to the operator module at every step.[3]

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
  - *1st visit:* Initial EEG recording without training (single letters, words, and sentences)
  - *2nd visit:* Training (Short words + short sentences)
  - *3rd visit:* Training (Medium sized words+ Medium sized sentences)
  - *4th visit:* Training (Long words + long complex sentences)
  - *5th visit:* Final EEG recording after practice (same difficulty for single letters, words, and sentences)

Electrophysiological Measurements

Biosemi System

- 33 scalp sites, 2 bipolar eye monitors
- Recorded at 1024 Hz sample rate
- Re-referenced offline to bilateral ear lobe electrodes
- 10 to 200 Hz band pass (24 dB/octive)
- 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 contian 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 P300s.

Figure 6: Dr. Davies and the research assistants putting an EEG cap on the participant.

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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2. Anderson, C., Davies, P. L., Gavin, W.J. (2011) Removing Barriers to the Practical Use of Non-Invasive Brain-Computer Interfaces. Abstract for Grant Proposal to NSF. Colorado State University. Fort Collins, CO.
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