Investigation of Optimal Stimulus Type for an Auditory Based Brain-Computer Interface

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Research Objectives

• To develop and auditory-based binary decision Brain-Computer Interface (BCI) system, with a focus on optimal stimulus type

• Designed to aid patients with severe ALS who are “locked-in” and cannot rely on muscular or ocular means of communication (Ohki et al. 1994)
Brain-Computer Interface

• BCI connects the brain and a computer system without the body’s normal output pathways (Wolpaw et al. 2002)

• Electrodes used to collect neural signals analyzed by discrimination and mathematical algorithms
Auditory Neural Response

- An attended stimulus results in a negative peak in EEG activity dispersed around the vertex of the brain approximately 100-200 ms after the stimulus (Hillyard et al. 1973)

http://www.freepatentsonline.com/7081085.html
Auditory BCI

- Auditory BCI systems have been achieved with numerous selectable stimuli, however the systems did not function for all subjects (Klobassa et al. 2009) (Furdea et al. 2009)

- Other systems have been binary-decision, but proved applicable to all subjects and with greater accuracy (Hill et al. 2005) (Kanoh et al. 2010)
- Drifting interstimulus period proposed by Hill et al. 2005
  - Proven to be effective stimulus method in the 2005 and unpublished 2009-10 study

- Fixed interstimulus period proposed by Kanoh et al. 2008
  - Limitations: stimuli not presented in binaural fashion, only offline analysis used
Methods

- Electroencephalography (EEG)
- 16 electrodes
- Stereo Headphones
- Logistic regression analysis
- MATLAB data analysis

Methods

- **One trial:** directional arrow, stimuli presented, subject response
- 20 trials per run
- 12 runs per subject
- Alt. conditions every 3 runs
- 9 subjects given drifting cond. First
- 7 given fixed cond. first.
Methods

• Use classification software
• After each run data is input into MATLAB cumulative analysis and used for future classification
• Subject’s first run in each condition not put through predictor
Subject Performance in Both Conditions
Statistical Analysis

- Wilcoxon Sign Rank test
- Used to detect a difference in the mean accuracies for the two conditions
- P-value of 0.0016
Statistical Analysis

- Wilcoxon Sign Rank test
- Used to detect difference in performance between first and last runs for Fixed Condition
- P-value of .0109
Results

- **Fixed-phase more accurate**
- Subject able to differentiate between the streams despite time lock and the computer classification is easier

- **Evidence of improvement**
- This may be due to computer’s improved subject specific profile
- Longer-term data is needed to explore further learning
Conclusions

- Proof of function for auditory BCIs
- This time using only 16 channels
- Clearly stimuli time-locked to each other are more useful
- Increase in performance during initial sessions
References


• Piccione F et al., P300-based brain computer interface: reliability and performance in healthy and paralysed participants, Clinical Neurophysiology 117 pp. 531–537 2004


Future Research

- Varied speed of stimuli
- Long-term research to analyze improvement
- Apply useful application to binary choices