Raw Data Algorithm Comparison

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Harry Durbin, Jes Parker, Millard McElwee

Introduction

Brainwaves are signals sent when neurons communicate with each other. These waves are typically measured with an EEG (or an "electroencephalograph") by placing sensors on the scalp. The five most common brainwaves are delta, theta, alpha, beta, and gamma. Each wave has a unique frequency range and affects how people handle stress, focus, and sleep. All five brainwaves are produced simultaneously; however, the ratio of these waves vary depending on the tasks people perform.

Table 1. Brainwaves at Various Activity Levels

Brainwave Type	Frequency range	Mental States and Conditions
Delta	0.1Hz to 3 Hz	Deep, dreamless sleep, non REM sleep, unconscious
Theta	4 Hz to 7 Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8 Hz to 12 Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12 Hz to 15 Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16 Hz to 20 Hz	Thinking, aware of self & surroundings
High Beta	21 Hz to 30 Hz	Alertness, agitation
Gamma	30 Hz to 100 Hz	Motor Functions, higher mental activity

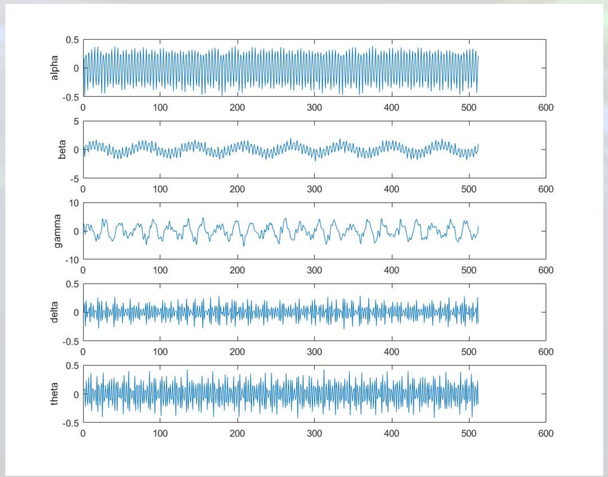

Figure 1. Brainwave Frequency Types

P-300 Trials

The P-300 wave is a unique response in the brainwaves to a visual stimuli which is unexpected to the observer. A trigger card was dealt, and the time was measured to determine if the brainwaves had a marked P300 wave response. In addition to having a P-300 wave, we hypothesized the card viewer would naturally have a high attention level (Alpha- and Beta-Waves) until the point of the trigger card being dealt, and afterward become more relaxed and rise into higher meditative level. (Delta-Waves).

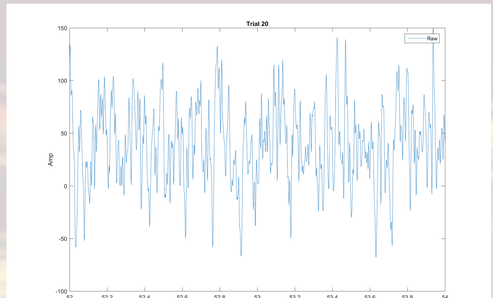

Figure 3. P-300 Trial

Steady State Visually Evoked Potential (SSVEP) Trials

The Steady State Visually Evoked Potential (SSVEP) is a phenomenon that occurs when the retina is excited by a visual stimulus and the brain generates electrical activity at the same frequency of the visual stimulus. A Brain Computer Interface (BCI) was tested using Matlab's Psychtoolbox to flash an image of "yes" at various frequency. The end goal was to allow a user to select an image based on focusing on that image. The frequency of the image should begin to match the frequency of electrical activity in the brain.

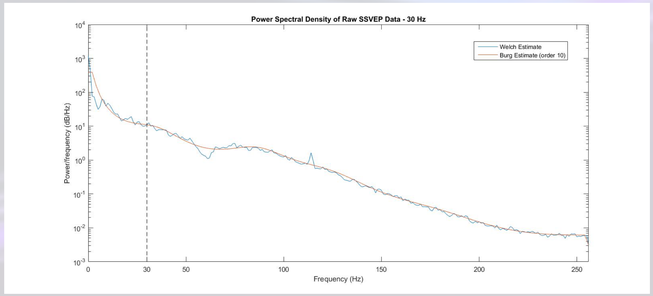

Figure 4. SSVEP Trial 30 Hz

Results

P300: We did not observe the P300 response in the Mindwave processed signals. These processed results are only output at 1Hz, while the raw signal is available at 512 Hz. In addition, the magnitude of this wave is not significant enough to noticeably stand out.

SSVEP: While it is possible to choose a filter and PSD algorithm combination that will give a significant increase in power at the stimulated frequency, that combination varies dramatically between tests and stimulation frequencies. We concluded that the Mindwave headset raw data does not contain enough information to support a BCI using SSVEP.

Figure 5. SSVEP Trial 30 Hz with Filter

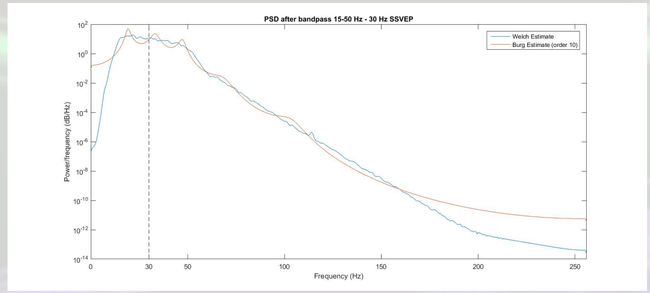

Figure 6. SSVEP Trial 15-50 Hz with Filter

Conclusions

Table 2. Project Summary

Objective	Result
Acquire raw singal data	With the Mindwave headset, used the Neurosky SDK Thinkgear.dll for packet acquisition, and Matlab to store, process, and visualize data.
Investigate the proprietary Neurosky algorithms	Able to reproduce a portion of the brainwave types, but not others.
Investigate the P300 response	Unable to notice any type of response. There could a combination of factors to explain.
Investigate the SSVEP	We could not detect brainwave increases at the corresponding flashing frequencies.