Determining the reliability of a dry, wireless EEG system

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Overview

Electroencephalography (EEG) is used to record electric potentials on the scalp from the summed activity of many neurons in the brain.

Traditional EEG systems have considerable limitations, including the inability to analyze large motor tasks such as gait, that dry, wireless EEG systems may ameliorate. However, it remains unknown if the dry wireless system produces a similar signal as the wet wired system across different tasks.

We hypothesize that the Cognionics HD-72 dry, wireless headset will obtain a comparable signal to that of the wet, wired Biosemi.

Participants and Task

Three healthy, right-handed volunteers aged 19 to 21.

Two electromyography (EMG) sensors were placed on each participant, one on the first dorsal interosseous (FDI) and one on the extensor digitorum communis (EDC). EMG and EEG data were collected for each participant using MotionMonitor® under three conditions:

- Rest: The participant focused his or her eyes on a specific point without auditory cues.
- Listen: The participants remained still while listening to a series of acoustic tones (50 ms, 500 Hz, 80 dB).
- Move: The participants then tapped their finger with the acoustic tones.

These conditions were then completed for two separate collections, one with the Biosemi system at 2048 Hz and one with the HD-72 headset at 300 Hz.

Data Analysis

Signal Processing:

- The kinematic position data were run through an automated program to compute amplitude and inter-movement interval (IMI).
- EEG signals gathered from both systems were run through ElectroMagnetic Source Estimation (EMSE), which applied Laplacian, High-Pass (70 Hz), Low-Pass (0 Hz), and Bandstop filters (55-65Hz).
- Movement onset was marked using EMG and position signals, and data were epoched (-500ms to 500ms) relative to movement onset.
- Epochs with eye blinks and any extraneous noise were rejected.
- Epochs were averaged across each condition (Rest, Listen, Move).
- A Fast Fourier Transform (FFT) was completed for each condition.
- The power spectra were normalized so total power in each spectrum was equal to 1 and then summed for each participant across each condition. Frequencies of interest are the alpha (8-12 Hz) and beta (13-30 Hz) bands.

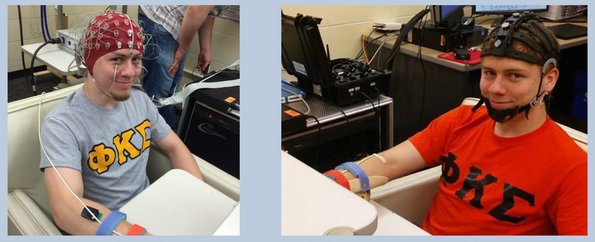

Figure 1. Traditional wired and dry wireless EEG systems.

Statistical Analysis:

- To compare peak amplitude and IMI, a paired t-test was completed for each participant.
- To analyze spectra between systems, the mean spectrum of each condition was divided by the mean spectrum of the other system, resulting in an F distribution.
- 95th percentile confidence limits were obtained from an F table using the total number of frequencies (1-40 Hz) as the degrees of freedom.
- Any value below or above these limits designated a significant difference between spectra (Fig. 2).
- Significance was set at $\alpha = 0.05$.

Results

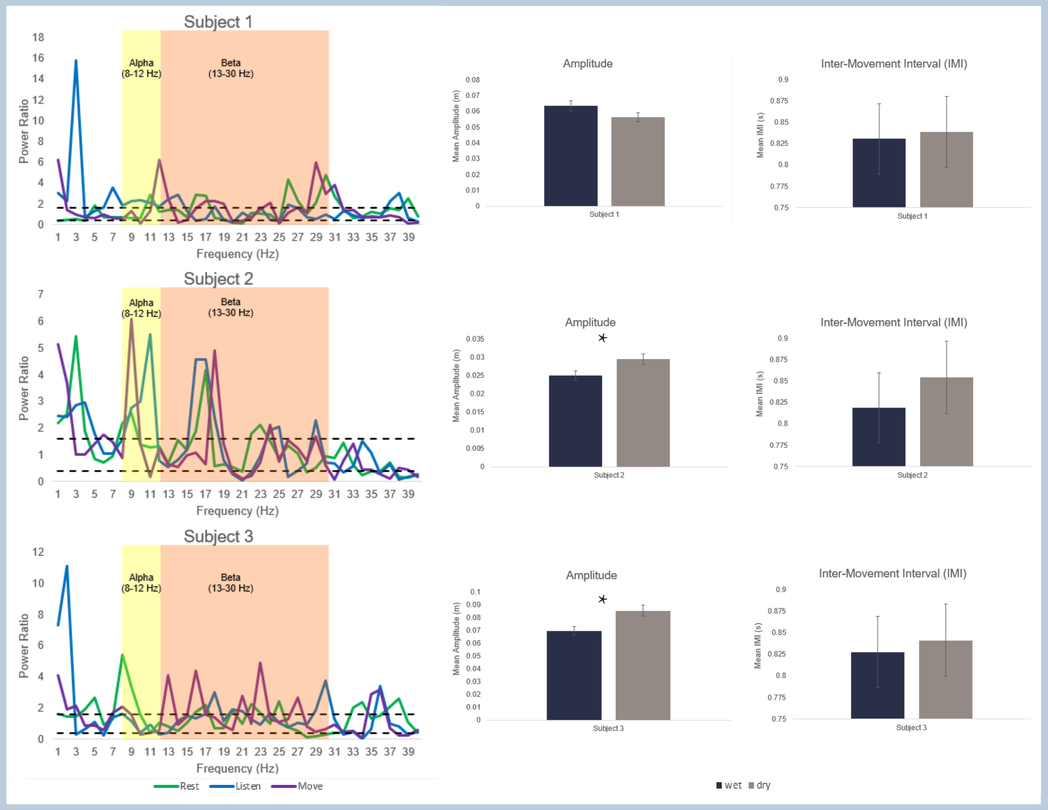

Figure 2. The ratio of normalized power across frequencies is shown for the three conditions for each subject. Any value above or below the dashed line (F statistic = 1.59 and 0.41) represents a significant difference between comparisons at the $p < 0.05$ level.

Figure 3. Mean peak-to-peak amplitude for both systems is shown in the left column. Mean timing accuracy (IMI) across both systems is shown in the right column. Asterisks indicate significantly different values from paired t-tests at $p < 0.05$.

Discussion

The power spectra were significantly different between the wet and dry systems across multiple frequencies, regardless of whether movement kinematics were different or similar.

Potential sources of error include: (1) Movement variability; (2) Manual sychronization of triggers during dry, wireless collection; (3) Small sample size. There is not sufficient evidence to conclude that the dry wireless system and the wet wired system produce comparable signals. Continued research is needed to validate the use of the dry wireless system for more complex movement tasks.

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