Time-Frequency Analysis of EEG During a 75-Minute Class

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Introduction

- Smith et al. (2003) identified two cycles lasting for periods of two and five minutes in the performance of a 30-minute continuous performance task. Arruda et al. (2009) reported that these same two and five minute cycles were observed in the presence or absence of higher frequency EEG activity recorded during the same 30-minute task.

- The purpose of this study was to assess the degree to which cycles of EEG activity are observed while students attend lecture-based classes. In particular, we were interested in the presence of cycles lasting two and five minutes, as observed in previous research.

- We recorded EEG while participants attended a 75-minute class and used a time-frequency analysis to detect periods of time over which cycles in EEG activity are observed.

Method

- Sixteen undergraduates participated in this study (3 male, 16 female; mean age = 22.06, SD = 1.81).

- EEG was recorded from the left-frontal (fp1) electrode location using a wireless EEG system (OpenBCI) for the duration of a 75-minute lecture class.

- Using a sampling rate of 250 Hz, EEG was recorded continuously from nine participants during a class beginning at 8 AM and from seven participants during a class beginning at 12:30 PM.

- Three-second segments of artifact-free EEG were extracted every five minutes throughout each 75-minute recording for a total of 16 segments for each participant. A sample of 10 seconds of EEG is displayed in Figure 1.
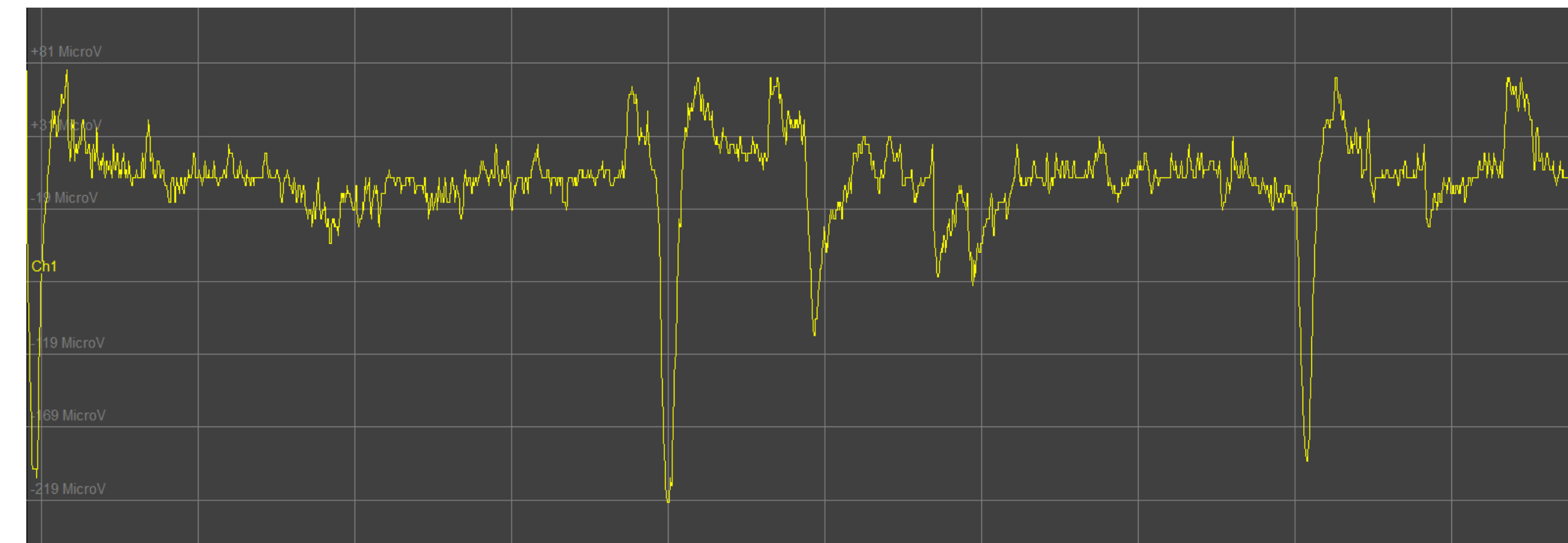

Figure 1

- A spectral analysis was performed on each EEG segment to calculate the degree to which each detectable frequency between 1 and 50 Hz was present. The degree to which a specific frequency is present is referred to as a value for the "power" of that frequency.

- Values for both frequency and power were converted to logarithmic units because the relationship between log-frequency and log-power is fit well by the pattern on a straight line.

- For each segment, we predicted values for log-power from values for log-frequency. We used the slope of the regression line as a measure of the degree to which the higher frequencies (13-50 Hz) were present. See Figure 2 below for a sample log-log plot.
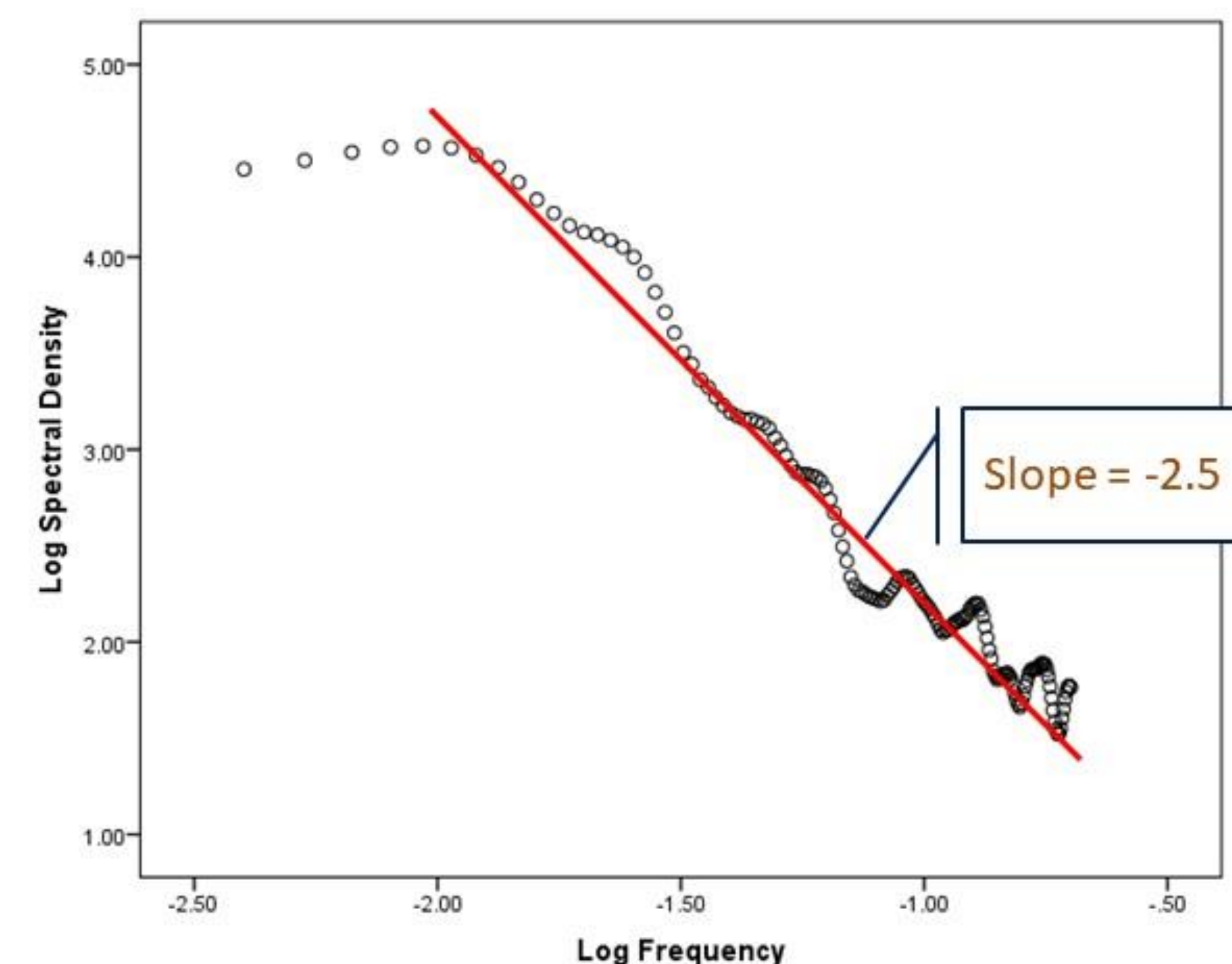

Slope = -2.5

Figure 2

Results

- For seven participants in the 8 AM section, a significant effect of Time During Lecture was observed, $F_{(15, 90)} = 1.842$, $p = .040$, eta-squared = .235, indicating that significant differences were present among mean slope values obtained at the 16 measurement points.

- An autocorrelation analysis of the mean log-log slopes obtained every five minutes indicated that participants in the 8:00 AM class completed cycles of steep (less high frequency activity) to shallow (more high frequency activity) to sleep slopes every 20 minutes.

- No consistent pattern of change was observed for participants in the 12:30 class.
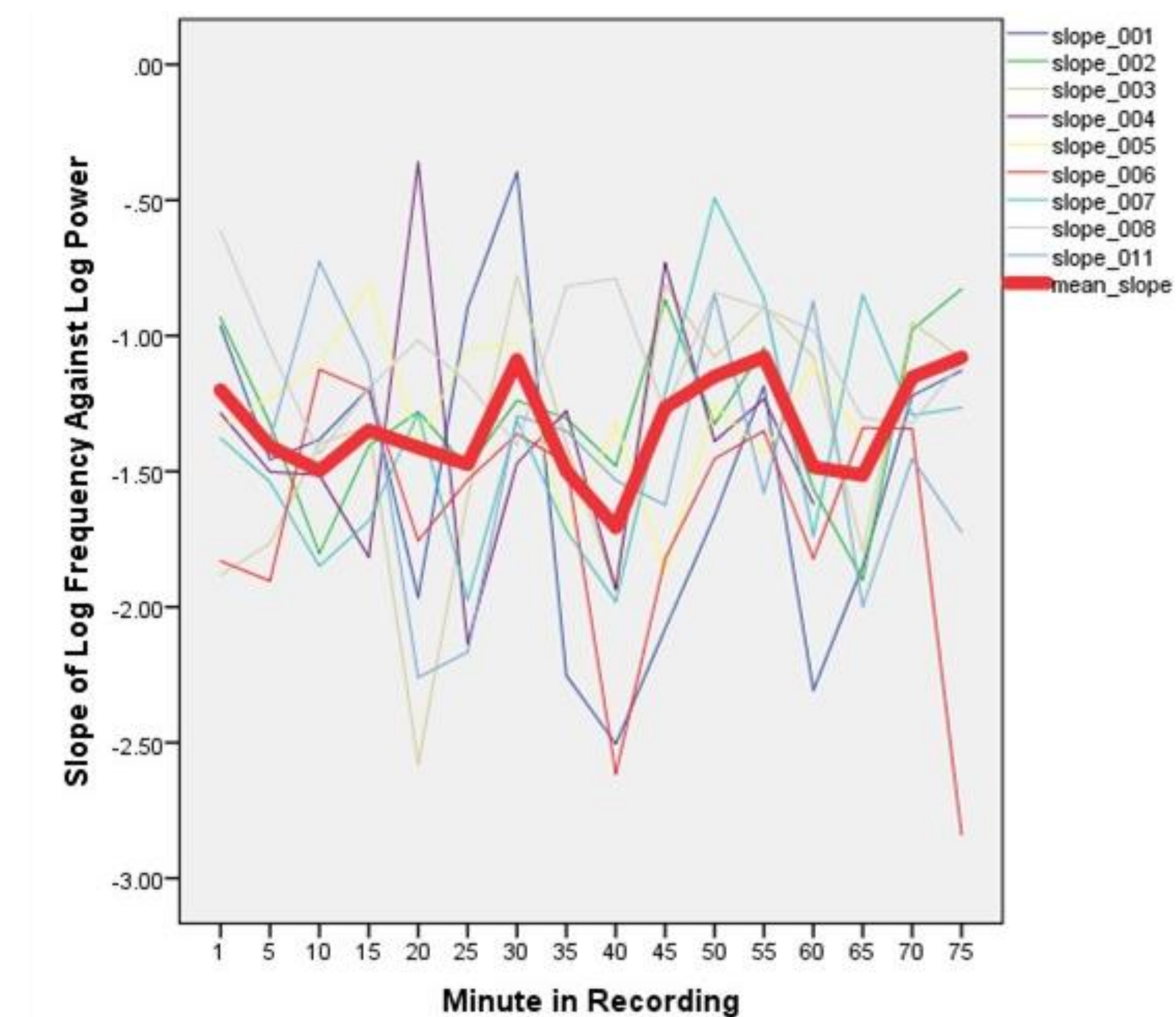

Figure 3

Discussion

- Evidence was obtained for 20-minute long cycles in high frequency EEG activity for participants attending lectures at 8:00 AM

- No consistent pattern of change in the EEG frequency spectrum was observed for participants in the 12:30 PM class.