Within-subjects Modulation of EEG Alpha Activity by Cardiac Vagal Control

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Introduction

- Major depressive disorder (MDD) is a major public health concern around the globe in the 21st century and has been projected to be the 2nd leading cause of disability by 2020 [1,2].
- Resting frontal EEG alpha asymmetry has been identified as a stable and reliable biomarker of MDD [3].
- Respiratory Sinus Arrhythmia (RSA), an index of cardiac vagal control, has also been linked to MDD. Specifically, low RSA could serve as a risk factor of depression [4,5].
- However, little research has examined the relationships between these two biomarkers

Aim & Hypotheses

- Investigate the dynamic relationship within persons over time between EEG activity and respiratory sinus arrhythmia in the context of major depression disorder
- **Hypothesis 1:** Frontal EEG alpha asymmetry is moderated by RSA.
- **Hypothesis 2:** Single site EEG alpha power is moderated by RSA.

Methods

- **Participants:** 220 young adults, mean age of 19.1(±1.74 SD), 71 males, 149 females, 108 with a history of MDD, 112 without a history of MDD.
- **Procedure:**
- Participants were screened for exclusionary criteria during both the phone and intake interviews by graduate-level clinical rater at the University of Arizona. History of MDD was determined using the SCID. Depression severity was assessed with the BDI-II the first day of data collection. Two resting EEG/EKG sessions were completed each day, on four separate days with no fewer than 24 hrs. between visits.
- **EKG Recording and Preprocessing**
- EKG was recorded in a Lead 1 configuration on a Synamps2 system with Ag/AgCI sensors attached on collarbones, sampled at 1000 hz
- Inter-beat interval (IBI) series was extracted from the EKG signal using QRSTool, software available from the senior author
- The IBI series was converted to a time-series and filtered using an optimal FIR filter to extract the high frequency band (.12-.4 hz) activity
- Instantaneous phase and amplitude information was extracted from the band-passed IBI time series using the Hilbert transform. Amplitude is the focus of this investigation, which reflects the real-time vagally-mediated changes in heart rate (Fig.1)

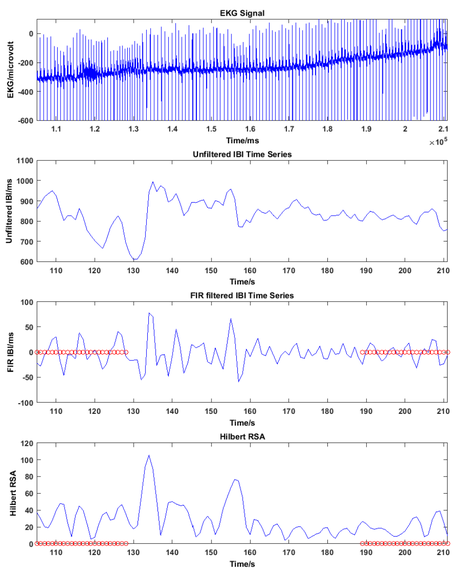

Figure 1. EKG Data Preprocessing

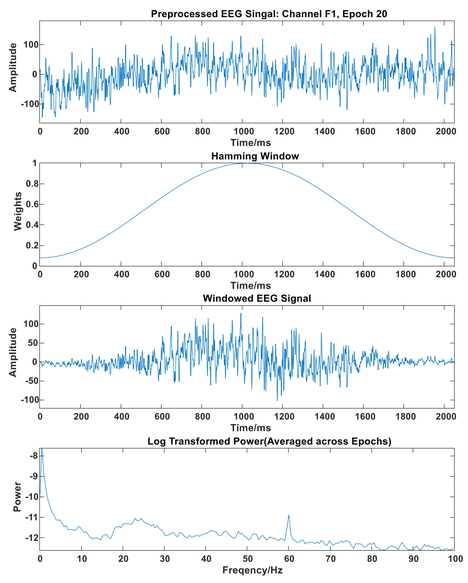

Figure 2. EEG Data Preprocessing

- **EEG Recording and Preprocessing**
- Eight one-minute blocks of EEG data were recorded using a sixty-four channel Neuroscan Synamps2 system, sampled at 1000hz
- EEG data were spatially-transformed using the current source density (CSD) algorithm
- Each one-minute resting EEG segment was divided into 2.048 s epochs, overlapping by 75 %
- Epochs were subsequently classified as either above or below the median RSA based on median Hilbert amplitude within the epoch
- The alpha power values for each epoch at 59 electrode sites were obtained using FFT and then averaged across the epochs (Fig.2)
- Frontal alpha asymmetry scores (ln(Right)-ln(Left)) were calculated at F8-F7,F6-F5,F4-F3,F2-F1.

Results

- Contrary to our first hypothesis, there was no significant difference in frontal alpha asymmetry at any of the frontal regions as a function of RSA level, and this nonsignificant relationship was not moderated by lifetime MDD status(Fig.3 & Fig. 4).

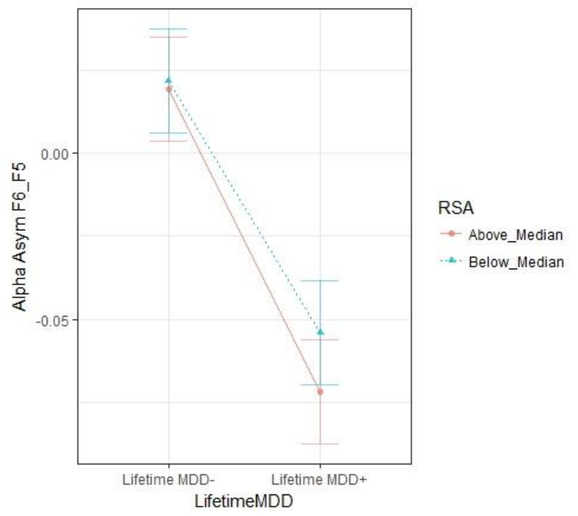

Figure 3. Alpha Asymmetry at F6-F5 by Median RSA and Lifetime MDD Status for the eyes open condition

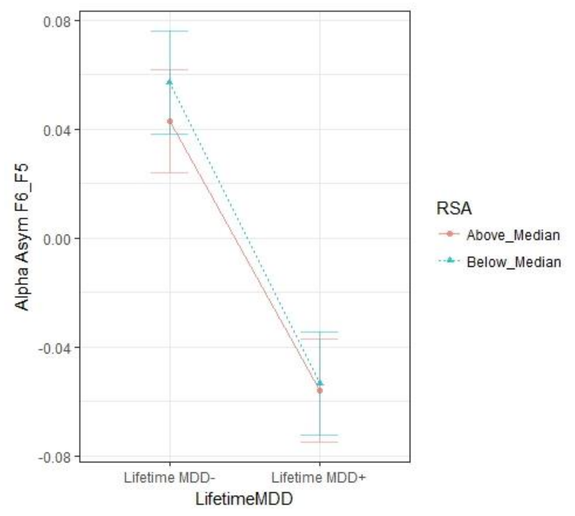

Figure 4. Alpha Asymmetry at F6-F5 by Median RSA and Lifetime MDD Status for the eyes closed condition

- However, within-person alpha power is modulated by RSA. Single site alpha power (not asymmetry) was significantly higher at 35 scalp sites when RSA was higher, but only during the eyes closed condition. None differed for the eyes open condition (Fig.5)

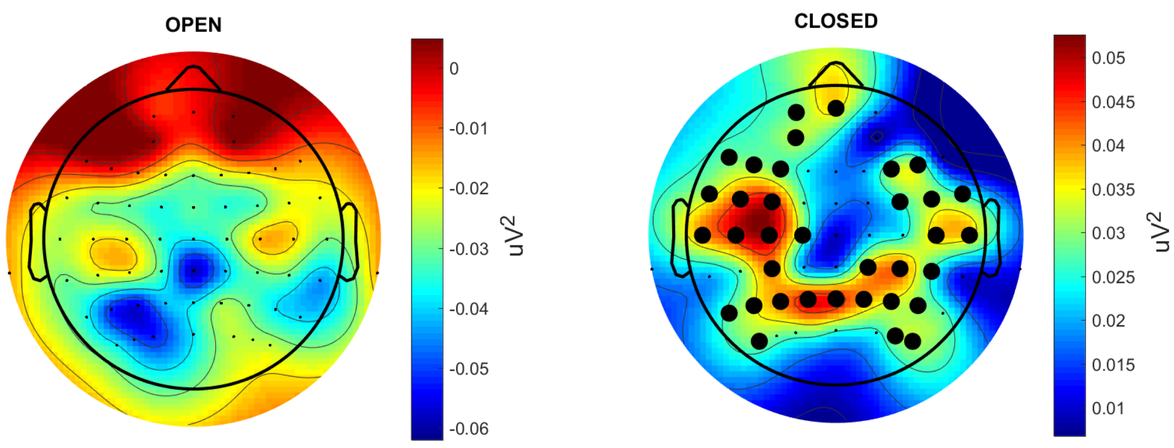

Figure 5. Alpha power difference by median RSA

Conclusions

- Frontal alpha asymmetry was not moderated by RSA level within participants over time for either depressed or non-depressed participants.
- In contrast to asymmetry scores, the raw alpha power at many individual sites varied within person as a function of RSA, with greater resting alpha power for high RSA epochs compared to low RSA epochs for many frontal and most parietal sites.
- Future work need to address the specificity of the effects to Alpha, and determine whether MDD status may interact with the relationship between scalp EEG power and RSA within persons.
- Future work might also explore lagged associations given the different time scales of EEG and cardiac vagal control (RSA).

References

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