Exploring the Relationships between EEG Activity and RSA in Major Depressive Disorder

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Independent Researchers Investigating Emotion

Introduction

- With an average lifetime prevalence of 8-12%, 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 has been identified as a risk factor of depression [4,5].
- However, little research has examined the relationships between these two biomarkers

Specific Aim

- Investigate the dynamic relationship within persons over time between EEG activity and respiratory sinus arrhythmia in the context of major depression disorder

Hypotheses

- **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 hr. between visits

Methods(cont.)

- **EKG Recording and Preprocessing**
- EKG was recorded in a Lead 1 configuration on a Synamps system with Ag/AgCl 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)

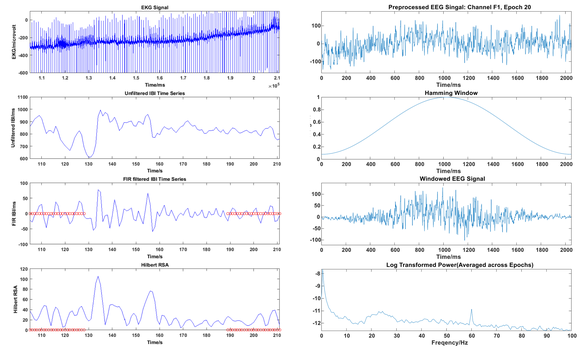

Figure 1: EKG Data Preprocessing Figure 2: EEG Data Preprocessing

- **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 all 64 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 MDD status (Fig.3) or sex (not plotted here)

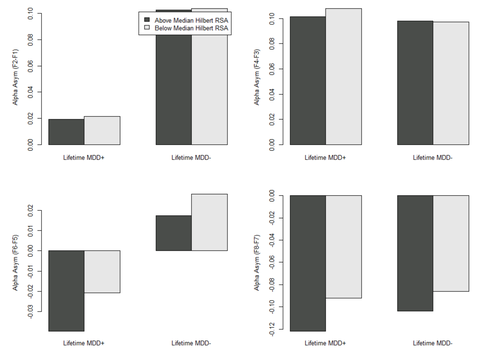

Figure 3: Frontal Alpha Asymmetry by Median Hilbert RSA

- Within-person alpha power is modulated by RSA. Single site alpha power (not asymmetry) was significantly higher when RSA was higher at 14 scalp sites (Fig.4)

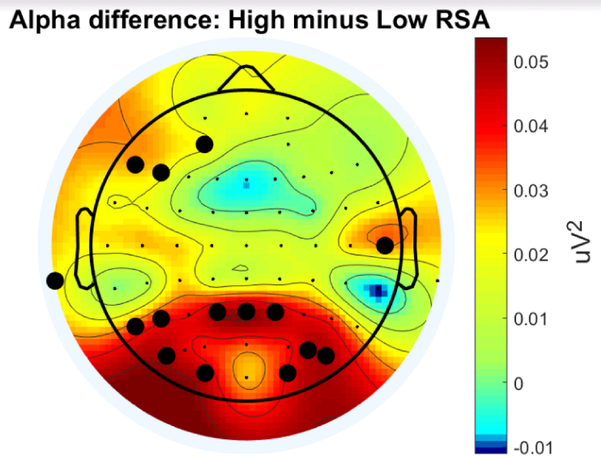

Figure 4: Topography alpha power difference (significant at sites depicted with black dot)

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 as a function of RSA, with greater resting alpha power for high RSA epochs compared to low RSA epochs for most frontal and parietal sites
- The relationship of cardiac vagal control to EEG power needs further exploration, but suggests the possibility of vagally-mediated brain-heart interactions related to alpha power.

Future Directions

- Examine the relationship between the EEG alpha power/ asymmetry using for time-lagged versions of the RSA signals, as the time course of effects of autonomic control and EEG are likely different.
- Examine the potential cross frequency power correlation between the EEG and RSA signals
- Investigate the directionality of the relationships between the EEG and RSA signals using the Granger prediction method

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