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

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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.

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(±7.4 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.

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.

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).

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).

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.

References


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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 is 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.

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 QRS-Tool, 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 (12-44 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).

Results

Figure 1: EKG Data Preprocessing

Figure 2: EEG Data Preprocessing

Figure 3: Frontal Alpha Asymmetry by Median Hilbert RSA

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