Linking Resting State EEG Asymmetry To Resting State fMRI With Simultaneous Recordings

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Overview/Summary

- Frontal EEG alpha asymmetry has been related to trait emotion and psychopathology in dozens of studies, and has shown promise as a possible marker of risk for Major Depressive Disorder (MDD).
- Surprisingly little is known about which neural systems may be indexed by surface EEG asymmetry.
- Because network connectivity is increasingly observed to be aberrant in MDD, and because EEG asymmetry likely reflects activity in distributed systems, we examined the correspondence between surface EEG asymmetry and resting state (RS) connectivity assessed with fMRI.
- Two RS networks were derived, one using the subgenual ACC as a seed, the other the dorsal ACC, as abnormal activity in these ACC regions are among the most replicated findings in MDD.
- Simultaneous EEG was corrected for gradient and BCG artifacts, and CSD-transformed to attenuate distal contributions.
- Lateral frontal EEG asymmetry was significantly negatively related to connectivity in the left inferior frontal gyrus.
- The present findings of less relative left frontal activity (indexed by EEG) being related to increased connectivity of left IFG to two ACC-seeded RS networks is consistent with: 1) Hyper-connectivity in RSfMRI emotion networks in MDD; 2) Frontal EEG asymmetry findings of less relative left frontal activity in risk for MDD.

Results

EEG Alpha Asymmetry is Negatively Correlated with IFG Connectivity in Two ACC-seeded Resting State Networks

Spatially-enhanced EEG asymmetry (using CSD transform) at sites F8-F7 is related to resting state connectivity between left inferior frontal gyrus and two ACC-seeded networks.

Dorsal ACC-seeded Network

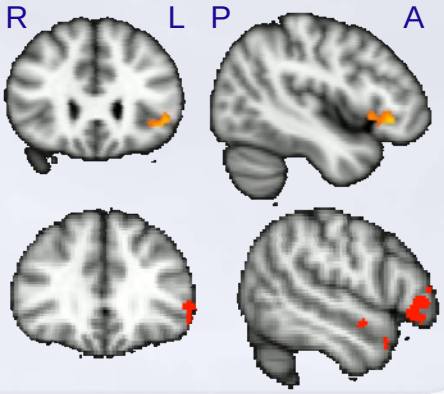
Center of the depicted cluster is (x,y,z) -46, 28, -4 MNI coordinates.

Largest correlation: r = -0.69

Subgenual ACC-seeded Network

Center of the depicted cluster is (x,y,z) -54, 28, -4 MNI coordinates.

Largest correlation: r = -0.71

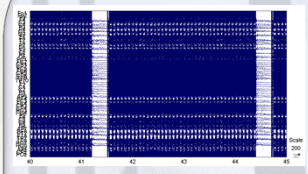


Methods

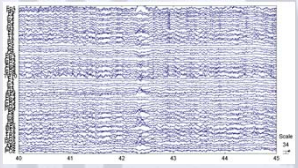
Subjects and Procedure

- Twenty-three medically- and psychiatrically-healthy female volunteers (mean age: 22.4 ± 2.3; range 19-28 years)
- Resting EEG for 8 minutes with eyes open and closed
- EEG (64 channels) recorded during BOLD imaging in 3T Siemens Magneton Trio, with Brain Products BrainAmp MR.
- EEG Sample rate = 5000 Hz, bandpass 0.1-250 Hz; synched to MR trigger for precise alignment with gradient switching
- fMRI details: EPI sequences; TR=3.2 secs; TE=30 msec; flip angle = 90°; FOV=192 mm; matrix = 64 x 64 mm²

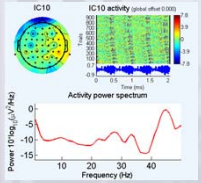
EEG Processing



EEG segment showing the large gradient-induced scanner artifact



The same EEG segment following removal of gradient artifact and ballistocardiogram (BCG) artifact



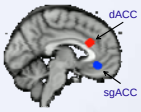
Data were epoched into 2.048-sec overlapping epochs. ICA was used for further artifact detection and removal. Sample scanner-related residual IC is depicted at left.

Alpha Asymmetry scores at lateral frontal regions (in red) were used to predict RSfMRI connectivity

Final Processing Steps:

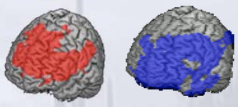
- Data transformed using a current-source density (CSD) transformation;
- FFT with Hamming window applied to each epoch
- Spectra were averaged across epochs
- 8-13 Hz Alpha power extracted
- Asymmetry scores at lateral frontal leads of interest: ln(right) – ln(left)
- These asymmetry scores (at sites in red at left) were examined in relationship to resting-state fMRI connectivity

RS fMRI Processing



- Selected the subgenual ACC (sgACC) as one seed region and dorsal ACC (dACC) as the other, based on the observation that abnormal activity in these regions are among the most replicated findings in MDD.
- Analysis of resting scans involved a 2-step procedure:
  - Scans were motion corrected, highpass filtered (60s), spatially smoothed (5mm), and then the motion and CSF parameters were modeled as nuisance regressors.
  - The mean time course within each ACC region was extracted and normalized, then entered as a regressor with the input data being the scaled residuals from step one.
- Resulting maps were spatially normalized to the standard MNI atlas and then Fisher Z transformed and combined at group level using the OLS model in FSL.

RS Network resulting from seeds in dACC (left) sgACC (right)



- Each subject had alpha asymmetry scores, and each subject had connectivity values at each voxel in the network.
- Correlations summarized the regions within each resting-state network where connectivity strength was predicted by resting frontal alpha asymmetry (Figures at Top).

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