Does alpha-band EEG activity in eyes-closed rest index a unitary state over time?

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INTRODUCTION

The EEG alpha rhythm is characteristic of the awake state, is enhanced by eye closure and attenuated by task performance. As such, alpha has long been considered a correlate of introspection and disengagement with the environment. Functional neuroimaging studies suggest that the interhemispheric alpha asymmetry, measured by the relative alpha power differences across hemispheres, is associated with increased activity in the default system. However, the implied model assumes that alpha variability can be used as a marker of activity in the default system. We examined this hypothesis by comparing alpha BOLD correlations over two different durations of continuous recording (5 and 20 minutes).

METHODS

Subjects: Thirty-four right-handed, healthy human subjects (ages 19-54, 20 females, 4 replicates) were recruited from the campus of Washington University under a protocol approved by the University’s Human Studies Committee. All subjects gave informed consent and were paid for their participation.

Data collection and analysis: Whole brain fMRI (Siemens Allegra 3T scanner; TE = 30 ms, 4 mm voxels, 3013 volumetric, 1 sec gap) was acquired in the eyes closed resting state using a sinc-trap waveform. Runs were each 20 minutes (512 volumes) or 20 minutes (398 volumes) in duration. Preprocessing of the BOLD time series included head motion correction within and across scans and atlas transformation on the basis of a T1-weighted structural image. EEG data were simultaneously acquired (DC-3500 Hz, 20 KHz sampling rate) using the MagLmk™ (Compumedics Neuroscan, TX) system (modified 10/20, 64 electrodes) and the Synamps2™ amplifier. Gradient artifact was reduced using Scan 4.5 software. Ballistic-cortical artifact was reduced using in-house software. Intracranial alpha power (8-12 Hz) was computed with a canonical hemodynamic response function and correlated with the BOLD timeseries on a voxelwise basis. A fixed effects analysis was performed on group data.

RESULTS

A. Alpha:BOLD. Fixed effects analysis of group data (N=25, p=0.05 corrected) wherein subjects lay quietly at rest with eyes closed for 3X5 minutes. The spontaneous EEG (O1 electrode) was filtered (alpha, 8-12 Hz), the power time series calculated (2 sec), and correlated with a canonical hemodynamic response and correlated to the simultaneously acquired BOLD time series on a voxelwise basis. Comparison to Fig. 1B shows a strong correspondence to portions of the default network, notably the PCC.

B. Functional connectivity. Random effects analysis of group data (N=34, p=0.01 corrected) wherein subjects lay quietly at rest with eyes closed for 3X5 minutes. Functional connectivity (fMRI) was performed as previously described (Fox et al., 2005) using a seed in the default system (posterior cingulate/premotor, PCC). This analysis clearly shows the default network in addition to an anticorrelated network of regions related to attentional processing (Corbetta et al., 2002).

CONCLUSIONS

While there are differences in the extent of alpha BOLD correlations with the length of time over which individuals lay in a state of eyes closed rest, these differences do not appear to define distinctly different sets of network activity. Interestingly, while there are clear similarities in the network structure of the alpha BOLD correlation data to portions of the default network, these similarities do not strengthen with prolonged periods (here 20 minutes) of eyes closed rest. In addition, while individual subject's data can be classified into two clusters based upon a measure of dreassness (decreased ATR), these differences do not translate to distinctly different regional network structure in comolutional data.

REFERENCES

FOX MD, Snyder AZ, Vincent JL, Corbetta M, Van Essen DC, Raichle ME (2005) PNAS 102:9673-9678

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