Aging effect on the resting state: two complementary approaches with the same fMRI datasets

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Introduction

Cognitive aging has been studied with cognitive tasks, but recently the resting state has also gathered attention because of its potential reflection of various states of the brain including aging. The resting state has been studied by both fMRI and EEG, but findings between the default mode network shown in fMRI studies and spontaneous alpha-power fluctuation demonstrated in EEG studies are not necessarily compatible. The present study aimed to investigate the aging brain with two different approaches, namely the alpha-power correlation and functional connectivity by simultaneous EEG-fMRI recording.

Methods

Eighteen healthy adults (11 young, mean age of 23.9 years, and 7 elderly, mean age of 66.9 years, all right-handed males) participated in this study. Written informed consent was obtained from all participants, and the experiment was approved by the ethics committee. Participants were instructed to close their eyes and keep awake during simultaneous EEG-fMRI recording for 420 seconds. fMRI data collection was performed with GRE-EPI (3T, Slices = 39, TR = 2000ms, TE = 24ms, FA = 90, Thickness = 3mm, Gap = 0.75mm, FOV = 192mm, Matrix = 64x64). Image processing and analyses were performed with SPM8 (The FIL Methods Group, Wellcome Trust Centre for Neuroimaging, Institute of Neurology, UCL) running under MATLAB 7.9. Preprocessed data were resampled to 2mm isometric and smoothed with 8mm FWHM Gaussian kernel. For functional connectivity analyses, group ICA of fMRI toolbox (GIFT) [1] was used for each group separately. For the alpha-power-correlation analysis, EEG were processed with EEGLAB [2] to extract temporal fluctuation of the occipital alpha power using ICA and wavelet. It was then convolved with canonical HRF to serve as regressors of the individual data analyses. For RFX analysis, one-sample t-test was performed (cluster level $P < 0.05$, FDR corrected).

Results

ICA successfully identified alpha component in 10 out of 11 young participants. However, it was successful in only 2 out of 7 for the old group. This may indicate age-related changes in alpha band activity. In order to identify the responsible cortical network, the alpha-power-correlated regions were identified for young group (Figure 1 left) to find the corresponding network in functional connectivity maps. Functional connectivity analyses found 9 physiologically valid cortical patterns out of 20 components for both groups, and one of them was identified as probably corresponding to the alpha-power-correlated network. When comparing these networks, old groups showed more diffusive pattern, which may explain spatio-temporally disorganized alpha waves.

Conclusion

Alpha-power correlated regions of the young group suggest that these regions are subject to age-related changes, which may result in degeneration of temporal organization of alpha-band activity which temporal ICA is sensitive to. Functional connectivity analyses on fMRI suggested that probably corresponding cortical network exists in the old group, but the spatial pattern is altered to be more diffusive compared to that of the young group. The results support conclusion that the alternation of the functional connectivity may be responsible for the 'missing' alpha-band activity with the old group.

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[2]Delorme A, Makeig S. J Neurosci Methods 134(2004)9-21.

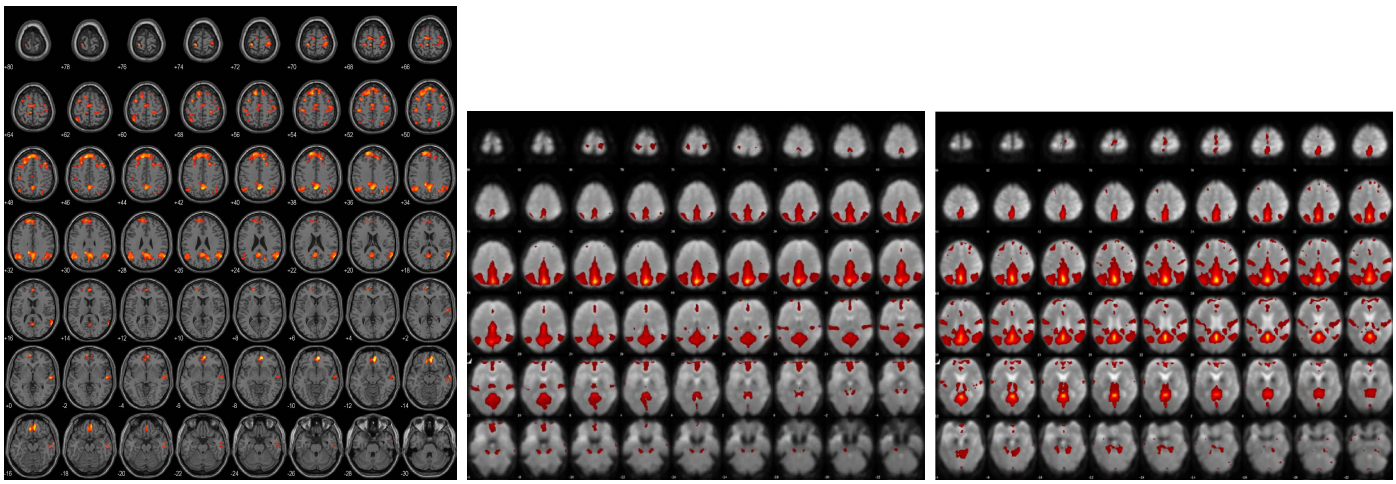

Figure 1 Left, cortical areas of the young participant group (n = 10) that showed negative correlation to the alpha-power fluctuation. Note that ICA could not reliably find alpha component from elderly participants and therefore the data are not shown. Middle, one of functional connectivity maps of young participants (n = 11). Right, one of functional connectivity maps of old participants (n = 7).