Aging effects on the functional connectivity in the resting brain

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Introduction

Functional connectivity (FC) provides a new perspective to look at the brain either during task performance or the resting state. FC discrepancies have been demonstrated between normal youths and older adults by several groups [1-3] using task related fMRI. Independent of external imposed task, FC can also be assessed using resting fMRI. The default mode network (DMN) [4] represents a major interest in recent brain function studies, as it could be deactivated during task performance [2] and could be altered by some brain diseases [9]. Previous studies have shown the aging effect in resting FC based on independent component analysis or concurrent task involved fMRI defined region-of-interests (ROIs) [5]. No published work has assessed the aging effect on resting FC in the DMN using the seed region based method. We reported here some preliminary results of the aging inter-region FC in the normal brain using resting fMRI. Two seed regions were defined in two very established parts of the DMN: the ventral anterior cingulate cortex (vACC) and the posterior cingulate cortex (PCC).

Materials and Methods

Thirty one healthy subjects (mean age= 40.42, range= 20 - 72, SD=18.33, 12 male) were scanned with signed written consent form approved by local IRB. MR imaging was conducted in a 3-T Siemens whole-body scanner. High-resolution structural images were acquired for spatial brain normalization using a 3D MPRAGE sequence(TR/TR/TI=1620/3/950ms). Gradient-echo echo-planar imaging sequence was used for BOLD fMRI data acquisition with parameters of: TR=3s, TE=30 ms, FOV = 220x220 mm^2, matrix=64x64x40, slices thickness= 3 mm. Participants were asked to lie still in the scanner at rest and keep eyes open. 220 images were acquired.

All data preprocessing was performed using SPM5 (http://www.fil.ion.ucl.ac.uk/spm) based batch scripts [6], including realignment; coregistration; smoothing with an isotropic Gaussian filter (FWHM=6 mm); low-pass filtering with a Butterworth filter (cutoff frequency = 1/8 Hz), and a high-pass Butterworth filtering (cutoff frequency = 1/128 Hz). A multiple regression model was built to filter fMRI time series by including the estimated head motion time courses, the global signal, and signal series within the CSF, and white matter as the covariates. DARTEL [7] was used to generate a local template and warp each individual's brain to the local template space. Seed regions were defined in vACC and PCC using Pick atlas utility [8]. The mean signal of each region-of-interest (ROI) was extracted for each subject and was then correlated to the rest of the brain to collect the FC maps. A simple regression was then performed to assess the aging effect of inter-region connectivity using the FC maps. The correlation map was thresholded at $P<0.001$ (uncorrected) and cluster size > 30 voxels.

Results and discussions

Fig. 1 shows the group level vACC connectivity map (Fig 1A) and the correlation to age (Fig 1B). As we can see that vACC is significantly ($P<0.05$ FWE correction) correlated to medial ACC and PCC; both PCC and hippocampi shows an age-dependent vACC FC decrease (blue spots in Fig 1B), but the bilateral frontal/precentral cortex show an age-dependent vACC FC increase (hot spots in Fig 1B). Fig 2 shows the PCC FC and its correlation with age. As shown in Fig. 2A, significant ($P<0.05$ FWE) PCC FC was found in ACC, prefrontal, and bilateral parietal cortex. Age-dependent PCC FC decrease was found in vACC and right prefrontal, while age-dependent PCC FC increase was found in left inferior frontal cortex and left parietal cortex. These results demonstrated that it is more robust to use PCC to assess the DMN than using ACC. Part of the reasons may be due to the age effect which is found to be more on ACC FC than PCC FC. In general, resting FC within the DMN is decaying with age, which is consistent with previous studies by other groups [1-3]. Both vACC and FCC FC in other regions go up and down during the normal aging process, indicating a possible increasing of decreasing functional integration between the seed region and these revealed regions. To further evaluate these findings, cognitive data would be required to relate them to cognitive function performance.

Reference

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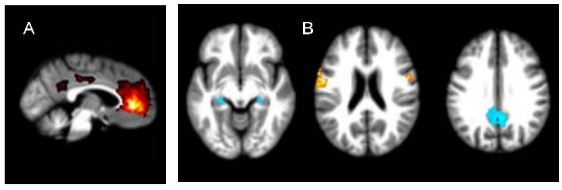

Fig 1. vACC connectivity map and the correlation to age.

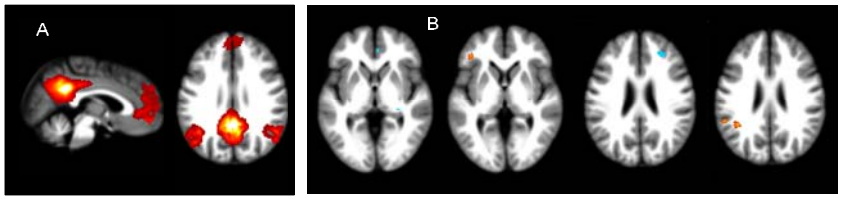

Fig. 2. PCC connectivity and its relation to age.