Varying resting-state brain activity in the "default-mode network" in post-stroke aphasia

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Background and purpose

Aphasia, the loss of the ability to produce or comprehend language, is a common consequence of left hemispheric stroke. Previous functional imaging studies on aphasic stroke are dominated by investigating brain activation during language performance accompanying recovery of language function. In the present study we aimed to investigate the changes of intrinsically organized default mode network (DMN) in the resting brain in expressive aphasia by functional MRI (fMRI).

Methods

Fifteen patients with expressive aphasia due to an infarction of the left middle cerebral artery territory received resting fMRI examination at subacute phase of disease, and 15 age-matched normal subjects were selected as control group. A 1.5 T unit with gradient echo - echo planar imaging sequence sensitive to BOLD contrast was used. For the fMRI data, several preprocessing steps were used, including (1) correcting for within scan acquisition time differences between slices; (2) realigning the volumes to the first volume to correct for interscan movements; (3) spatially normalizing to a standard EPI template and making a resample; (4) spatially smoothing; (5) linear regression to remove the influence of head motion, whole brain signals and linear trends; (6) temporally band-pass filtered. For 13 regions derived from Fox *et al.* [1], a resting-state time series was extracted respectively for each subject. The functional connectivity was produced by averaging the BOLD time series separately in the two regions, and then computing the Pearson's correlation coefficient between the two averaged time series. The resulting correlation then was transformed to approximate Gaussian distribution using Fisher's r-to-z transformation. For each subject, then, we created a square (13 x 13) correlation matrix. We performed two-sample t tests ($P < 0.05$) on all potential connections represented in the correlation matrices between normal subjects and patients. Connections that were significantly different between groups, but $z<0.1$ in both groups, were not displayed.

Results

In healthy subjects, the regions in DMN are strongly functionally connected (Fig. 1a). In the patients, however, functional connectivity in DMN decreased (Fig. 1b). But posterior cingulated cortex and retrosplenial showed the highest functional connectivity in both groups. As compared to the controls, most nodes within the DMN exhibited reduced functional connectivity in aphasic patients, and among those nodes, the pair of bilateral inferior temporal cortex showed the strongest reduced connectivity. The only one pair of medial prefrontal cortex (anterior) and cerebellar tonsils showed increased functional connectivity as compared to healthy subjects (Fig. 1c).
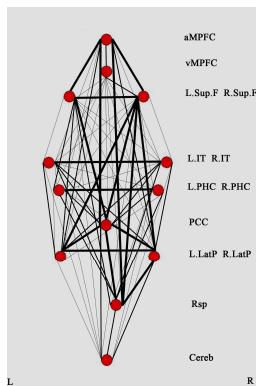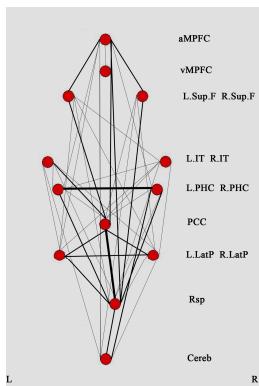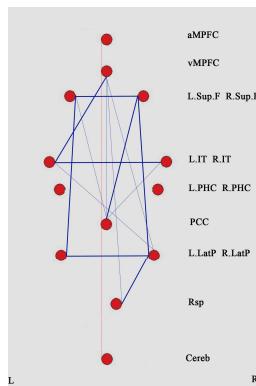

Fig. 1a   **Fig. 1b**   **Fig. 1c**

Fig. 1 Graph visualization of the correlation represented in a pseudoanatomical organization. In normal subjects, the default regions are highly integrated (a), however, sparsely connected in patients (b) (line width is proportional to the connection strength). Fig. 1c shows statistically significant differences in functional connectivity between normal subjects and patients. Blue lines represent significantly greater functional connectivity in normal subjects than inpatients. One connection (between anterior part of medial prefrontal cortex and cerebellar tonsils), was significantly greater in patients than in normal subjects (red line) (line width is proportional to significant level).

Conclusion

Our findings suggest that the varying functional connectivity in DMN in expressive aphasia may be brain reorganization secondary to the ischemic damage.

Reference

1. Fox MD, et al. Proc Natl Acad Sci USA, 2005, 102: 9673-9678.   2. Fair DA, et al. Proc Natl Acad Sci USA, 2008, 105: 4028-4032.