Intrinsic Resting State Functional Connectivity of Default Mode Network Predicts Attention Task Performance

P. Lin[1], N. De Pisapia[1], and J. Jovicich[1,2]
[1]Center for Mind Brain Sciences,University of Trento, Mattarello, Trento, Italy, [2]Department of Cognitive and Education Sciences,University of Trento, Rovereto, Trento, Italy

Introduction

The default mode network (DMN) is an intrinsic brain system that participates in internal modes of cognition. Neural activity and connectivity within the default network [1-4], which are correlated with cognitive ability even at rest. However, what remains unclear is the key issue of whether the inter-region functional connectivity within DMN is related to task performance. Here, we hypothesized that the strength of the functional connectivity (FC) within DMN is an index of the degree of regulation of task performance during attention task state. We found that some inter-region FC within DMN showed the significant negative correlations to reaction time during attention task. These results would suggest the important role of the inter-region FC within DMN during resting state linking to the cognitive performance.

Methods

Tasks and MRI acquisition*:* 14 subjects participated in this study. For the resting-state scan, subjects were instructed simply to keep their eyes closed and to not think of anything in particular. The scan lasted for 10 min. After resting state task, the subjects were imaged followed by visual attention task blocks in which they were instructed to respond as quickly as possible to a lateralized visual target with an ipsilateral or a contralateral button press, according to the instruction (respectively coded by a square and a diamond) that they saw at the beginning of each trial. A masked instruction (smaller square or diamond) or neutral shape (star) preceded subliminally each visible instruction. A 4.0 T Bruker Medspec scanner equipped with an eight-channel multi receive system was used. Structural images (3D MPRAGE, 1x1x1 mm^3, GRAPPA IPAT = 2, [5]) and BOLD EPI data, corrected for distortion with the PSF method [6]. (TR/TE = 2500/33ms, flip angle=73^0, 3x3x3 mm^3) were acquired.***fMRI data Analysis:*** fMRI analysis was performed in AFNI (Cox, 1996). Pre-processing consisted of motion correction, temporal band-pass filtering (0.01 Hz<f<0.1Hz), spatial normalization to standard Talairach space and spatial smoothing (Gaussian, FWHM 6mm). Several sources of nuisance covariates (six head motion parameters, signal from the white matter and the CSF) were eliminated using linear regression. To define key areas of the DMN a seed-based cross-correlation analysis was calculated by extracting the BOLD time course from posterior cingular cortex (PCC), then computing the correlation coefficient between that time course and the time course from all other brain regions. Temporal correlation coefficients relative to PCC were converted to z-scores by using Fisher's r-to-z transformation. To evaluate inter-region functional connectivity within DMN correlation with task performance, the major brain regions of interesting within DMN, each of the ROIs was defined as a spherical region with a radius of 5mm at the center of the obtained coordinates for each ROI.ROIs mean time series were estimated by averaging the times series of all voxels in these region. The Pearson's correlation coefficients were computed between each pair of brain regions for each subject, and then correlation matrix for each subject was obtained. Then we examine the inter-region functional connectivity within DMN correlation with task performance (Reaction time, RT).

Results and Discussion

We measured resting state inter-region functional connectivity within DMN correlation with task performance (RT).The Fig.1 shows scatter plots of significant negative correlations in PCC-dmPFC(r^2=0.36,p=0.01),PCC-vmPFC(r^2=0.24,p=0.04),PCC-RITC(r^2=0.27,p=0.03), dmPFC-RLP (r^2=0.23,p=0.04) and vmPFC-RLP (r^2=0.25,p=0.03) with RT. A number of recent studies reported that the strength of the resting state FC have a direct link to working memory performance [7-9]. In addition, inter-individual variability in behavioral reaction time has been investigated using FC and DTI [10].However, whether inter-region FC within DMN during resting state can directly linking to cognitive behavior is remains unclear. Functional connectivity assessed from inter-regional correlation of BOLD signal fluctuations may be correlated with behavioral performance. One possibility explains is that stronger functional connectivity probably permits more efficient communication among brain regions for supporting task performance. We found that the strength of the FC within DMN negative significant correlation between the strength of FC and RT of performance attention. Our data provide evidence that the inter-region FC of the default mode can predict attention on gonging task performance.

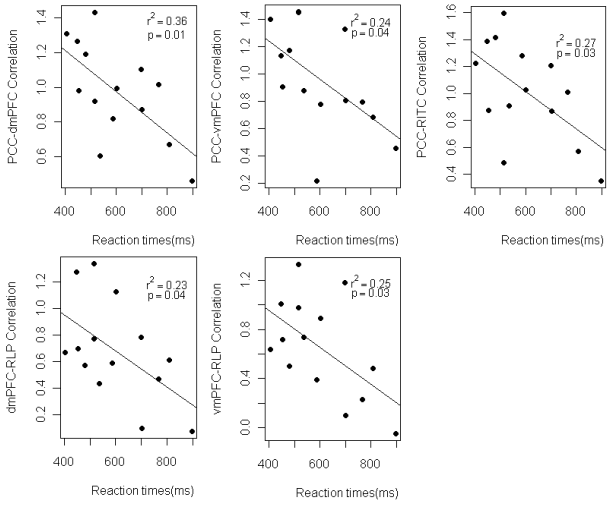

Fig. 1 Resting state inter-region FC within default mode network correlation with attention task reaction time. PCC, Posterior cingulate cortex; vmPFC and dmPFC, ventral and dorsal medial prefrontal cortex ; RITC, right inferolateral temporal cortex; RLP, right lateral posterior cortex.

Acknowledgments: Support for this research was provided by the government of the Provincia Autonoma di Trento,Italy, Project PAT Post-doc 2006.

References: [1] Greicius et al., PNAS, 100: 253-258, 2003. [2] Beckmann CF, et al., Philos Trans R Soc London Ser B, 360:1001–1013, 2005. [3] Calhoun, V.D., et al., HBM, 29:828-838, 2008. [4] Fox MD, et al., PNAS, 102:9673–9678, 2005. [5] Roebroeck et al., NeuroImage, 25:230–242, 2005. [5] Papinutto N et al., ESMRMB, 2008.[6] Zaitsev et al., MRM,52:1156-1166, 2004. [7] Hampson et al., J Neurosci, 26: 13338-13343, 2006 [8] Wang et al ., Hippocampus, 20: 345-351, 2010.[9] Wig et al., PNAS ,105, 18555-18560,2008. [10] Tuch et al., PNAS, 102, 12212-12217,2005.