

Deactivation Network of Working Memory in Schizophrenia: Functional MRI Study with Parametric Digit n-back Task

Q. Zhang¹, Y. Zhang², G. Yang³, and W. Li³

¹Department of Radiology, Tianjin Medical University General Hospital, Tianjin, Tianjin, China, People's Republic of, ²Tianjin Medical University General Hospital, Tianjin, ³Tianjin Medical University General Hospital

Background and Purpose

Working memory (WM) deficits plays an important role in cognitive deficits of schizophrenia. Task induced deactivation (TID) recently became the focus of fMRI study. This study aimed to explore TID network with fMRI and parametric digit n-back working memory task, and to explore the neural substrates of working memory impairment in high-performance schizophrenia.

Methods

Thirty-six right-handed paranoid and undifferentiated schizophrenia patients (diagnosed according to DSM-IV, 20 male, 16 female, age range from 28 to 52, and average 38 years,) and 36 matched healthy subjects were recruited in the study after signed a written consent. A parametric digit n-back (n=1, 2 and 3 respectively, 0-back as control condition) working memory task with increasing levels of difficulty was used during the study. Five 1-back, five 2-back and five 3-back blocks run alternately with 0-back block. The subjects view the stimuli through gaggle system (RT Company, USA). Each stimulus presented for 1 second, and the inter-stimulus interval was 2 second. Functional MRI was acquired on a GE 1.5T Twin Speed MR scanner with GRE-EPI sequence (TR/TE=3000/60ms, thickness=5mm, slice gap=0.5mm, FOV=24×24cm, matrix=64×64, 26 slices covered whole brain). According to the behavioral performance of 2-back task in experiment, the data of patients and healthy subjects whose accuracy exceeding or equal to 85% were used for further analyzing with SPM2. As a result, 20 healthy subjects (8 men and 12 women, average age 32) and 16 patients (8 men and 8 women, average age 34) were recruited finally. Significant threshold of t-test at voxel level for functional areas was $p < 0.05$ (corrected). The regions including more than 10 consecutive activated voxels were regarded as functional areas. Group analysis (including 0-back contrast to 1, 2, 3-back; 1-back contrast to 2, 3-back; 2-back contrast to 3-back) was performed to identify the deactivation brain regions in two groups respectively; inter-groups contrast maps were also acquired.

Results

TID network activated in healthy group include: bilateral ventral medial prefrontal cortex (VMPFC) and dorsal medial prefrontal cortex (DMPFC); bilateral cingulate gyrus (BA24/31); right inferior frontal gyrus (BA47); bilateral temporal pole (BA38) and bilateral postcentral gyrus (BA5) (Fig 1). The TID regions in schizophrenia were similar with those in healthy group, but the extent and intensity of activation was smaller (Fig 2). The TID regions in healthy group showed increased deactivation from 1-back to 2-back (Fig 3), but from 2-back to 3-back, only left insula (BA13) showed continuous deactivation. Dissimilar to healthy group, TID regions in schizophrenia didn't show increased deactivation with the load increasing, but presented with unchanged deactivation level or even decreased deactivation (Fig 4). TID regions in schizophrenia presented with more obvious decreased deactivation when compared with healthy group (Fig 5).

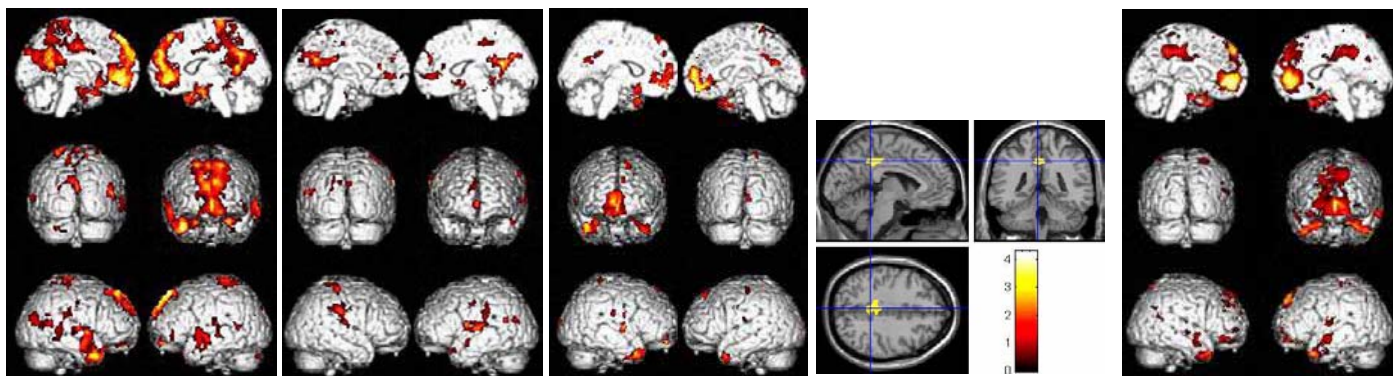


Fig 1

Fig 2

Fig 3

Fig 4

Fig 5

Fig 1 TID regions in healthy group: MPFC, cingulate gyrus, bilateral temporal lobe, left inferior frontal gyrus and left postcentral gyrus. **Fig 2** TID regions in schizophrenia: MPFC, cingulate gyrus, bilateral temporal lobe and bilateral postcentral gyrus. **Fig 3** Loading effect of TID regions in healthy group: shows increased deactivation of TID regions from 1-back to 2-back. **Fig 4** Loading effect of TID regions in schizophrenia: posterior cingulate showed decreased deactivation. **Fig 5** TID regions shows more obvious decreased deactivation during 3-back in schizophrenia than that in the healthy group.

Discussion

During performing WM and other cognitive tasks, some brain regions presented with deactivation, and this appearance may be a consequence of cross-modal inhibition mechanisms^[1]. In healthy group, WM related regions showed increased activation from 1-back to 2, 3-back, while TID regions presented with continuous deactivation. Ongoing processes of resting state and/or control baseline state and cognition processing state are two competing extremities of working memory. Brain resource shifting between the two extremities is the basis of TID. The deactivation degree of TID regions in schizophrenia decreased, reflecting abnormal resource reallocation, resulting in disappearance of the competing coupling relationship between “resting state and/or control state” and “external task state”, resulting in more WM regions to be operated, this is consistent with “cortical inefficiency” hypothesis^[2].

Conclusion

At different load levels, TID network shows decreased deactivation to a different extent, with most salience at higher WM loading level. Ineffective resource reallocation is the basis of WM deficits in schizophrenia patients.

References

- 1 Laurienti PJ, Burdette JH, Wallace MT, et al. J Cogn Neurosci, 2002, 14: 420-429
- 2 Jansma JM, Ramsey NF, van der Wee NJ, et al. Schizophr Res, 2004, 68: 159-171