Replicability of memory task-induced brain fMRI activation patterns in older adults

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Introduction

BOLD fMRI is a non-invasive neuroimaging method that has been used to study the neural correlates of complex cognitive processes. With this technique, it is assumed that when a brain region is employed to perform cognitive tasks, blood is redistributed and oxygenated blood density is increased in the area, making it relatively more "active" compared to it at the "resting" state. However, given that BOLD contrast is an indirect haemodynamic response-based measure of neural activity in the brain, questions remain as to whether fMRI signal will vary markedly with various physical, physiological, and cognitive factors, which may impact the reliability of task-induced brain fMRI activation results. This becomes a particularly serious concern for fMRI studies that involve elderly participants, considering that the physiological status of older adults is generally more variable than that of younger adults. The purpose of the present study is to investigate whether cognitive task-induced brain fMRI activation patterns can be replicated in older adults.

MRI acquisition

A 4-Tesla Varian-Oxford human imaging system was used for imaging data acquisition. Functional data were acquired using two-shot spiral readout (TR/TE=1000/15ms, flip angle=60°); 22 axial slices (5.5mm thick, 0.5mm gap, 240mm FOV, 64×64 matrix). A high resolution T1-weighted whole brain anatomic image was acquired using MPFLASH (240×240×192 FOV).

Methods

Six older adults (two females and four males, aged 67-90 years) had fMRI scans while performing episodic memory tasks by viewing pairs of standard line-drawing pictures. The encoding task involved identification of living versus non-living objects, while the retrieval task involved identification of objects that had been displayed previously versus objects that were displayed for the first time. Subjects were instructed to press either the left or right button on a response pad for each stimulus to indicate whether the target was on the left or right side of the picture pair (Figure 1). During each scan, subjects underwent two encoding sessions and two retrieval sessions in a counter-balanced order. Each session consisted of 30 stimuli composing five 36-second blocks. Each stimulus was displayed for five seconds followed by a 1-second fixation. Inter-block resting period lasted for 16 seconds, during which time a cross sign was displayed in the middle of the screen. All subjects were scanned twice under the same settings with the baseline and follow-up scans six to nine months apart. Whole brain activation maps of encoding and retrieval states were obtained for each individual. Data were preprocessed for motion correction, co-registration, spatial normalization, and smoothing and were filtered for low-frequency noise. A canonical haemodynamic response function with time and dispersion derivations was applied to model task onset and duration. Significance of contrasts was set at p=0.001 (uncorrected, extent=6). Imaging data analysis and processing were performed using GLM. Visual stimuli presentation and behavioral data collection (eg., accuracy and response time) were performed using Eprime.

Results

The behavioral accuracy of the encoding was over 90% while that of retrieval was over 80%. The response time for retrieval was much longer than that for encoding ($p<0.05$). For both tasks, there was no significant group difference between baseline and follow-up in either response time or accuracy ($p>0.05$). Both encoding and retrieval tasks evoked diverse cerebral cortical activation in the brain regions More extensive brain activation was associated with retrieval compared to encoding, especially in the prefrontal and superior parietal cortical regions, reflecting additional effort in coping with the greater cognitive challenge. The areas within known neural networks for memory processes showed relatively consistent activation at different scan times (Figure 2A). Nevertheless, inter-individual differences in task-induced brain activation patterns were observed (Figure 2B).

Figure 1: Example stimulus

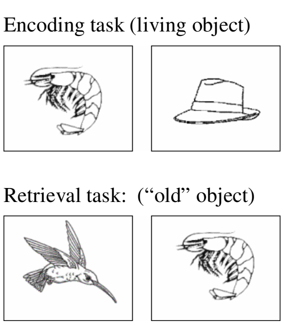
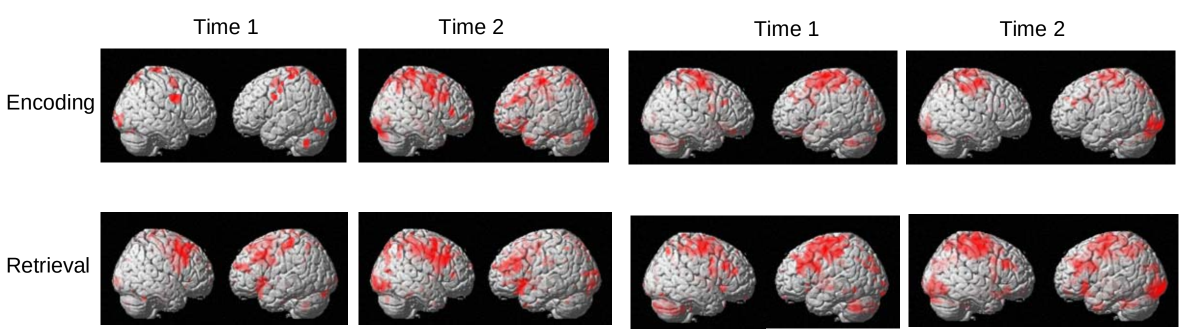


Figure 2: Brain fMRI activation maps at baseline and follow-up of two subjects (A: left panel; B: right panel)



Conclusion

Properly designed episodic memory encoding and retrieval tasks can generate sufficiently consistent brain fMRI activation patterns in older adults that reflect memory related neural networks. However, considerable variation exists in the brain activation of older individuals and care must be taken when activation maps of different subjects are analyzed together as groups.