Functional Connectivity during Memory Consolidation: A Resting-State fMRI Study

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Introduction

Memory consolidation is a brain process through which a short-term memory stabilizes into a long-term memory [1]. Consolidation is initiated by learning and lasts in the brain for a period of time after termination of the learning experience. Evidence has shown that the hippocampus is important for consolidating procedural memory in an implicit motor-sequence learning task [2]. The first resting-state fMRI experiment design was introduced by Biswel et al (1995). This technique can demonstrate functional connectivity between brain areas engaged by "default" mental processes. In this preliminary study, we employed a resting-state experiment design to reveal the functional connectivity among the hippocampus, posterior cingulated cortex (PCC), and middle temporal gyrus (MTG) during consolidation of memorizing easy and difficult English words that would result in good and poor memory respectively.

Methods

A word memorizing task including easy and difficult words was administered to each participant. Twenty words were used in each condition and the participants had forty seconds to remember the English spelling and corresponding Chinese meaning of each word. Three resting-state scans, 10 minutes for each one, were used for probing the functional connectivity at various times; the first one was taken before the memory task as baseline, the second one was taken right after the learning phase, and the third one were taken 3 hours later. After all the resting-state scans, a recognition test of judging words was administered to decide if a particular word appeared previously. Eleven participants (5 males and 6 females) joined in this experiment. TR was 2 seconds with 24 slices interleaved, in which the voxel size was 4*4*5 (mm^3) in an AC-PC orientation. All the functional data were preprocessed and analyzed using SPM5 and REST.

Results

To analyze functional connectivity, we selected three seed points, including the PCC, hippocampus, and MTG), all of which were active areas from the recognition test. The results from these three seed points showed consistent patterns for the after-3-hour scan. The difficult condition produced increased connection with the cuneus. The easy condition produced increased connections with cerebellum and prefrontal cortex.

Conclusion

In this study, we used a resting-state fMRI experiment design to study variations of functional connectivity among brain areas as memory consolidated. As seed points set at the hippocampus, PCC, and MTG, we detected increment in connection with cuneus in the hard condition, implying the engagement of visual analysis for difficult words. We also detected increment in connection with cerebellum and frontal cortex in the easy condition, reflecting the on-going neural activity as memory consolidated.

Reference

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2 . Albouy G, Sterpenich V, Balteau E, Vandewalle G, Desseilles M, Dang-Vu T, Darsaud A, Ruby P, Luppi PH, Degueldre C, Peigneux P, Luxen A, Maquet P., Neuron. 2008 Apr 24;58 (2):261-72.

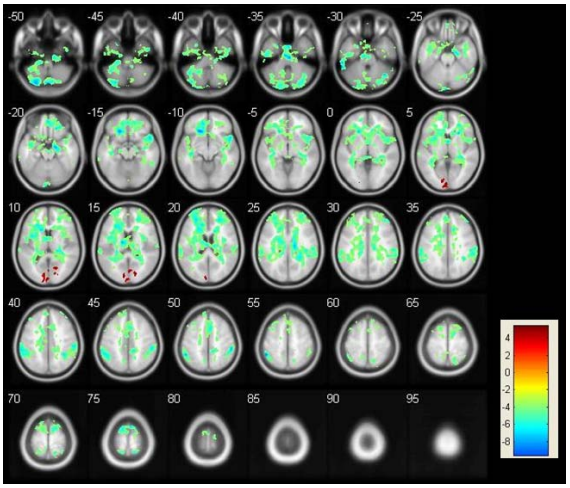

Figure 01. The difference of functional connectivity between the difficult and easy conditions as seed point set at hippocampus. (p<0.001, uncorrected)

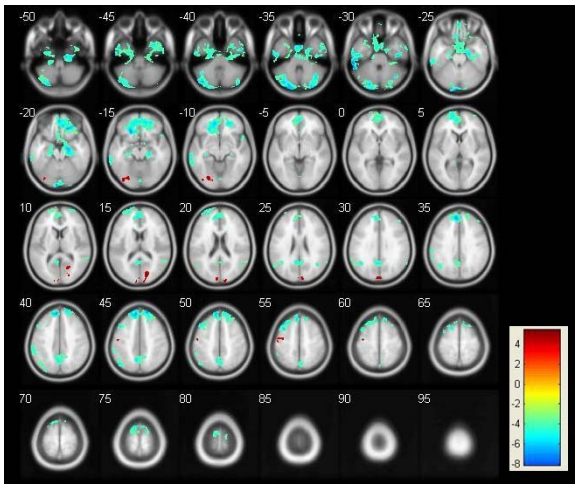

Figure 02. The difference of functional connectivity between difficult and easy conditions as the seed point set at the middle temporal gyrus. (p<0.001, uncorrected)