Anterior and posterior hippocampal memory networks in aging as revealed by resting state fMRI

Y.C. Shih[1,2], Kayako Matsuo[2], S.H. A. Chen[3], Toshiharu Nakai[4], Y.C. Hsu[5], F.H. Lin[1], and W.Y. I. Tseng[2]

[1]Institute of Biomedical Engineering, National Taiwan University, Taipei, Taiwan, Taiwan, [2]Center for Optoelectronic Biomedicine, National Taiwan Univerity College of Medicine, Taipei, Taiwan, Taiwan, [3]Division of Psychology, Nanyang Technological University, Singapore, Singapore, Singapore, [4]National Center for Geriatrics and Gerontology, Aichi, Japan, [5]Department of Biomedical Engineering and Environmental Sciences, National Tsing Hua University

Introduction

We performed resting state fMRI to investigate the functional connectivity of elderly people placing seed regions in the anterior and the posterior hippocampus. Aging effect has been shown in the hippocampus as the main node of the memory network [1]. Several studies demonstrated the discrimination between the anterior and posterior hippocampus, which may reflect different functions in memory [2-3]. We used a regression model to efficiently detect the functionally coherent cerebral regions with these hippocampus seeds on SPM software platform [4]. We hypothesized that elderly people show the different signal coherence pattern in the hippocampal memory network for the associated locations and the amplitude.

Methods

Fifteen right-handed elderly participants (50-72 years old, mean=65.73, SD=5.23) and Fifteen right-handed young participants (20-25 years old, mean=21.53, SD=1.6) who gave written informed consent were included in this study. Mini–mental state examination (MMSE) indicated no significant difference between the two groups. All images were acquired using a 3T MR scanner with a 12-channel head coil (Trio Tim, Siemens, Erlangen, Germany). A GE-EPI sequence was employed using the following parameters: TR/TE = 3000 ms/30 ms, flip angle = 90 deg, 39 slices, 3 mm slice thickness with 3.75 mm gap interleaved, FOV = 192 x 224 mm, matrix size 64 x 64, and 140 volumes. We used SPM8 (http://www.fil.ion.ucl.ac.uk/spm/software/spm8/) and in-house MATLAB codes for analyses. Individual data were preprocessed with the slice timing, realignment and spatial normalization to Montreal Neurological Institute (MNI) space, low-pass filtered at 0.08Hz, and spatially smoothened with FWHM 6 mm. We generated left and right hippocampus masks using established anatomy templates (WFU_PickAtlas 3.03, ANSIR Laboratory). We divided the hippocampus masks into anterior and posterior at y=-24 in MNI space [5]. Averaged signal time courses extracted from these 4 seed regions (left and right, anterior and posterior hippocampus) with their time derivatives were included in a general linear model of the first level statistics for each subject with regressors of spurious sources by the realign parameters and average intensity values from the CSF and white matter regions. We computed 6 kinds of contrasts: left anterior, right anterior, left posterior, right posterior, bilateral anterior and bilateral posterior hippocampus. The resultant contrast images were used at the second level random-effects group statistics ($p<0.001$, uncorrected). Using the results from the group statistics, we defined the following 3 regions of interest (ROIs): the insula, the anterior superior temporal lobe, and posterior cingulated cortex (PCC) obtained by the intersections of the anatomy masks and the group results from the coherence with bilateral hippocampus. These ROIs were applied to extract averaged voxel T value for the 6 kinds of contrasts in elderly and young individuals; the value indicates an index of the signal coherency with the seed region. Two-sample t-test was performed to compare the averaged voxel T values between elderly and young groups.

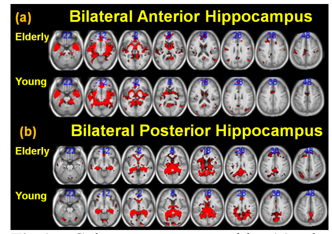

Fig.1: Coherence maps with (a) the bilateral anterior hippocampus seed, (b) the bilateral posterior hippocampus seed in elderly and young groups. ($p<0.005$, uncorrected)

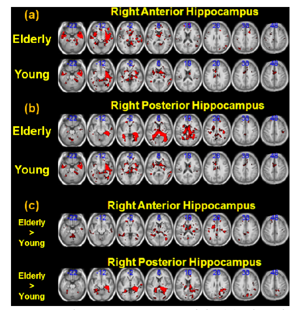

Fig. 2: Coherence maps with (a) the right anterior hippocampus seed, (b) the right posterior hippocampus seed in elderly and young groups. (c) Coherence maps with the right anterior and posterior hippocampus seeds in "elderly>young". ($p<0.005$, uncorrected)

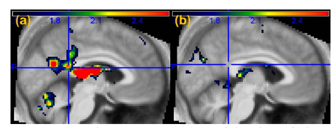

Fig. 3: Coherence maps with the right posterior hippocampus seed. (a) Elderly group, (b) young group. ($p<0.005$, uncorrected) The elderly group showed the right posterior hippocampus was coherent with the left PCC, but the young group did not show that. The color bar indicates T value at group level statistic. Red color means higher coherence with the right posterior hippocampus.

Results and Discussion

We found two memory networks associated with the anterior and posterior hippocampus, respectively; the anterior hippocampus had coherence with anterior part of the bilateral superior and medial temporal lobe, the insula, and the inferior medial prefrontal cortex; the posterior hippocampus had coherence with the PCC and the medial temporal lobe (Fig. 1-3). These regions may represent different memory functions; the insula and the anterior hippocampus were associated with emotional experience and memory [2]; superior temporal gyrus was involved in episodic memory; PCC and posterior hippocampus had a relationship with experienced spatial navigation [3]. Both elderly and young groups showed similar coherent maps in the two networks ($p<0.005$, uncorrected). Analyses using the averaged T values revealed that elderly group showed significantly higher coherent activation than younger group for the 2 kinds of contrasts: coherence with the right anterior hippocampus seed in the insula and in the anterior part of superior temporal gyrus respectively ($p=0.006$; $p=0.023$), and coherence with the right posterior hippocampus seed in the left PCC ($p=0.014$). The previous study presented that healthy elderly people had higher cognitive functions (i.e., episodic memory, semantic memory, and perceptual speed) to verify risky aversion [6]. Our findings suggested neural representations for the compensatory mechanism to enssure the maintenance of the aging brain.

Conclusion

Anterior and posterior hippocampal seeds revealed different memory systems, respectively. Elderly group demonstrated higher signal coherence in the left PCC with the posterior hippocampus, and in the right insula and the anterior part of superior temporal gyurs with the anterior hippocampus. The higher coherence in elderly might indicate a compensating mechanism in the aging brain.

Reference

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