Comparison of a Mirror Neuron System among Elders with
Mild Cognitive Impairment, Alzheimer’s Disease, and No Disease

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Abstract—Alzheimer’s disease (AD) is the most common cause of dementia. There are lots of old people suffering from the disease. Mild cognitive impairment (MCI) is a transitional state between normal aging and dementia. An individual with MCI has an increased risk of developing AD. The mirror neuron system (MNS), activated during the observation and execution of actions, has been linked with cognitive processes. The objective of this study is to examine the MNS abnormalities in elders with MCI and AD. Ninety-two subjects (5 MCI, 7 mild AD, and 80 cognitively normal) were studied by using functional magnetic resonance imaging (fMRI). In the fMRI experiment, subjects were asked to observe a video showing hand movement (tearing a piece of paper) and a control condition (observing a fixation point). The image data were analyzed using SPM2 (Statistical Parametric Mapping). There were significant activations of bilateral inferior frontal lobule and inferior parietal lobule due to the observation of hand movement. The brain activations of the normal group were statistical significant greater than those in the MCI and mild AD groups. There was no significant difference between the MCI and mild AD groups. Elders with MCI and mild AD had fewer MNS activations than the normal controls, suggesting that the dysfunction of MNS may underlie cognitive impairments in MCI and AD patients. These findings imply that fMRI is sufficiently sensitive to detect MNS changes occurring in MCI and AD.

Keywords—Mirror neuron system, Functional magnetic resonance imaging, Mild cognitive impairment, Alzheimer’s disease

I. INTRODUCTION

The mirror neuron system (MNS) is activated during both the execution of actions and observation of actions made by another individual [1]. The hypothesis was forwarded to named these neurons that mirror neurons. First discovered in the macaque brain, mirror neurons have been identified in the ventral premotor cortex (area F5) and the rostral inferior parietal cortex (area PFG and PF) [2]. The existence of an analogous MNS in humans has been demonstrated by independent investigations. In humans, the observation of actions done by others activated homologous areas in the rostral part of the inferior parietal lobe and the posterior part of the inferior frontal gyrus [3, 4, 5, 6, 7]. Functional magnetic resonance imaging (fMRI) that is a technique for measuring brain activity was used to localize the MNS. It works by detecting the changes in blood oxygenation and flow that occur in response to neural activity.

Alzheimer’s disease (AD) involves problem with memory, cognitive, behavior, mood, language, and judgment. AD is the most common form of dementia. Most often, it is diagnosed in people over 65 years of age. In 2006, there were 26.6 million sufferers worldwide [8]. Mild cognitive impairment (MCI) is a diagnosis given to individuals who have cognitive impairments beyond that expected for their age and education, but that do not interfere significantly with their daily activities. It involves problem with cognitive, memory, language, thinking, and judgment. MCI tend to progress to AD at a rate of approximately 10% to 15% per year [9].
Functional MRI is a noninvasive tool for detecting changes in brain function before an individual progresses to meet clinical criteria for dementia. As a functional measure, fMRI therefore should have an advantage in early detection over other imaging techniques that detect disease-related structural changes. Due to the MNS involving a range of important cognitive processes from action understanding [10], the aim of this study is to examine MNS differences in elders with MCI, AD, and no disease underwent fMRI while observing hand action.

II. MATERIALS AND METHODS

A. Subjects

MRI images of all subjects are from Thai Brain Mapping project of Ramathibodi hospital in Bangkok, Thailand. Informed consent was obtained from every subject. The project was approved by the Ethical committee of the Mahidol University. MRI images of ninety-two subjects, aged over 50 years-old were retrospectively studied: 80 cognitively normal subjects, 5 patients with MCI, and 7 patients with mild AD.

B. MRI scanner and scanning sequences

Functional MRI measurements were obtained on a 3.0 Tesla scanner (Philips, Intera) using echo-planar imaging (EPI). MRI scanning parameters were used: TR 2 s, TE 35 ms, FA 45°, 32 slices, 200 images per slice, slice thickness 4 mm.

C. Experimental protocol

While being scanned, subjects were asked to view tearing a piece of paper video. Action observation was contrasted with the observation of a fixation point, as a control condition. Hand action of tearing a piece of paper was presented in sequences 15 seconds long. Each sequence was presented 4 times during the experimental session. A fixation point was presented 20 s long.

D. Image analysis

Image analysis was performed by using MATLAB version 6.5.2.202935, MATLAB version 7.4.0.287(R2007a), SPM99 (Statistical Parametric Mapping), and SPM2. The EPI time-series data of every subject was set the origin at the anterior commissure to as close as the template. Pre-processing of the EPI images consisted of 5 steps. First, the images were coregistered with the 3d-images of each subject. Second, the images were realigned to correct for head movements between scans. Third, the images were corrected differences in slice acquisition times. Forth, the images were normalized to the standard template. Finally, the images were smoothed by using Gaussian filter of 8 mm full-width at half maximum. Then, fMRI detection was performed by convolve the EPI data with the SPM2 hemodynamic response function. Next, the contrast images of all subjects were run one-sample t-test by SPM2. Pixels of the activation map were identified as significantly activated if they passed the highest threshold of t-score (3.18) and belonged to a cluster of at least 4 activated pixels (P<0.001). The activated pixels were superimposed on high-resolution magnetic resonance scans of a standard brain.

III. RESULTS

Observation of hand movement determined frontal and parietal activations. Other activations (mostly occipital) will not be discussed here, because they were activations of visual areas with moving stimuli.

In the normal group, activations during observation of tearing a paper video are shown in Fig. 1. There were activations in area 6, 44, and 45 on both sides. In addition, activation foci were present in parietal lobule. These foci were located in area 2 and anterior intraparietal area, bilaterally.
Fig. 1 Projections of the brain activations during observation of hand movement on the lateral surface in the normal group (t>3.18, P<0.001) RH, right hemisphere; LH, left hemisphere

Figure 2 shows activation foci in the MCI group during observation of tearing a paper video. There were same areas of frontal activations as in the normal group. The activations of area 44 and 45 in right hemisphere were stronger than left hemisphere. And, there were bilateral activations of inferior parietal lobule only in area 2. These activations were weaker than in the normal group.

Fig. 2 Projections of the brain activations during observation of hand movement on the lateral surface in the MCI group (t>3.18, P<0.001)

Figure 3 shows activation foci in the mild AD group during observation of tearing a paper video. There were few activations of area 45 and 2 on both sides. The activations of area 45 in right hemisphere were stronger than left hemisphere. These activations in mild AD group were weaker than in the normal group.

Fig. 3 Projections of the brain activations during observation of hand movement on the lateral surface in the mild AD group (t>3.18, P<0.001)

Figure 4 shows a between-group comparison of the normal and the MCI group revealed that the difference was significant.

Fig. 4 A between-group comparison of the normal and the MCI group (t>3.18, P<0.001)

Figure 5 shows a between-group comparison of the normal and the mild AD group represented that the difference was significant.

Fig. 5 A between-group comparison of the normal and the mild AD group (t>3.18, P<0.001)
Figure 6 shows a between-group comparison of the MCI and the mild AD group. There was no significant difference between the both groups.

Fig. 6 A between-group comparison of the MCI and the mild AD group (t>3.18, P<0.001)

IV. DISCUSSION

The results of the present study show that observation of tearing a paper video activated inferior frontal gyrus and inferior parietal lobule, bilaterally. During observation of hand movement, the normal elders activated a neural network similar to several previous studies [3, 4, 5, 6, 7]. The results show that the MNS is involved in cognitive processes from action understanding [10].

During observation of hand movement, the activations of the normal elders were significant greater than those in the MCI and mild AD elders. These findings suggest decreased MNS activations involve in cognitive deficits.

The activations during observation of hand movement in the MCI and mild AD elders were no significant difference. These results may occur from small sample size of MCI and mild AD subjects in the experiment due to the preliminary study.

V. CONCLUSION

Elders with MCI and mild AD had fewer MNS activations than the normal controls. The results suggest that the dysfunction of MNS may be at the core of cognitive deficits observed in MCI and AD. In addition, these findings indicate that fMRI is adequately sensitive to detect MNS changes in MCI and AD patients.

REFERENCES


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