The Bold Signal Response Differences Between Encoding and Recognition Memory of Face-Name Associations

M. Robinson[1], J. Wang[2], P. J. Eslinger[3], M. Meadowcroft[1], X. Golay[4], and Q. X. Yang[2]

[1]Neural and Behavioral Sciences, Penn State College of Medicine, Hershey, PA, United States, [2]Radiology, Penn State College of Medicine, Hershey, PA, United States, [3]Neurology, Penn State College of Medicine, Hershey, PA, United States, [4]National Neuroscience Institute, Singapore

Introduction: Identifying the neural substrate for face-name associative learning and memory is an important area of research pertinent to understanding human social interaction, memory, and the underlying pathophysiology of disorders such as prosopagnosia, Alzheimer's disease, and traumatic brain injury [1,2]. Although there have been several functional imaging studies of face-name processing, the precise role of neural structures and the networking involved remain unclear [3]. To further investigate these issues, we evaluated the BOLD response to face-name pairings during encoding and memory recognition tasks, comparing the levels and locations of activation between two tasks. Based on a neural systems model of encoding and memory, we hypothesized that the largest differences between the tasks would be evident in the visual association cortices, the hippocampal region, and the prefrontal cortex, and that significantly higher BOLD responses would be identified in the right fusiform gyrus, right hippocampus, and left prefrontal cortex during encoding.

Methods:

Study Participants: The fMRI protocol was conducted on 6 healthy normal volunteer participants (20-50 years of age, 4 males and 2 females). All subjects had at least a high school education. The data from two subjects were discarded because no performance was observed during the functional paradigm.

fMRI Study Procedures: The present study was carried out on a 3 T Philips MRI scanner. A boxcar paradigm was used, consisting of alternating intervals of baseline (blank screen with a small cross in the center) and experimental trials (encoding and recognition memory of face-name pairs). During scanning, black-and-white faces with hair removed and names displayed below were viewed through a reflection mirror in front of the eyes of the subject. The encoding phase included multiple single face-name pairs, whereas recognition memory required subjects to identify which one of 4 names was associated with a specific face. Subjects responded to visual stimulation by pressing the buttons on a fiber optic button box. A series of T_2 *-weighted images (TR/TE/FA = 3600ms/30ms/90°, 28 axial slices, 2.5 mm slice thickness, FOV = 210 × 210 mm^2, acquisition matrix = 80 × 80, reconstruction resolution = 128 × 128, SENSE factor = 2, 64 repetitions) were generated for functional data acquisition. Each subject underwent two runs of the same paradigm with different face-name pairs.

Data Processing and Analysis: The fMRI data were processed with SPM2 [4]. Average activation maps for each task were generated. BOLD responses from sixteen selected regions of interest (bilateral prefrontal cortex, anterior and posterior fusiform, inferior temporal, occipital inferior, middle, and lingual gyrus, and the hippocampus) were measured and compared between the two tasks.

Results: Of the sixteen regions of interest, the right posterior fusiform gyrus and right hippocampus showed significantly higher BOLD response peak amplitudes in the encoding task than in the retrieval task ($p < 0.03$ and 0.01, respectively) (Fig. 1). In contrast, the left lingual gyrus BOLD response during the retrieval task was significantly higher than that during encoding ($p < 0.003$) (Fig. 1). Finally, our task-contrast average activation maps showed that activation of the left superior and middle temporal gyri and the right frontal superior medial gyrus were specific to encoding, whereas activations in the lingual gyrus bilaterally, parietal lobe, right frontal inferior triangularis, and right cuneus were specific to retrieval (Fig. 2).

Conclusion and Discussion: Even though the fusiform, lingual gyrus, and hippocampus were significantly activated in both encoding and retrieval tasks, the level of their associated BOLD responses differed significantly. The right fusiform gyrus and right hippocampus had significantly higher activation during encoding, consistent with prior knowledge of a right hemisphere dominance in face-name associations [5]. The lingual gyrus, which has not received much attention in face-name memory, showed specific increased BOLD response during the recognition memory task, suggesting a possible neural substrate for memory consolidation and long-term knowledge. In addition to evaluating BOLD responses, contrasting activation maps between encoding and recognition memory tasks revealed task-specific activation areas, such as the parietal lobe and the middle and superior temporal gyri. During encoding, the left middle and superior temporal gyri may be activated because of the lexical demands in face-name associative processing. Parietal lobe activation during recognition memory may reflect consolidation related multi-modal sensory convergence of visual and verbal stimuli. We propose that face-name encoding and memory entails complex feed-forward pathways from primary visual cortex to multiple sites in visual association cortices, temporal lobe, and prefrontal cortex during encoding, as well as the possible establishment of consolidated pathways in occipital, parietal and temporal cortices for long-term memory storage. The findings in this study indicate that the brain has multiple areas involved in both processes, yet there are definite differences in processing pathways as the information is fed forward in a posterior to anterior direction [6]. BOLD response level comparisons as well as comparing contrasting activation maps in face-name encoding and recognition memory tasks may contribute to further understanding of the neural systems underlying learning and memory.

References:

1. Haxby JV, et al. *Trends Cogn Sci* 4: 223-233, 2000.
2. Bodamen J. *Arch Psychiatr and Nervenkr* 179: 6-53, 1947.
3. Campanella S, et al. *Neuroimage* 14: 873-882, 2001.
4. Friston KJ, et al. *Human Brain Mapp* 1: 153-171, 1994.
5. Kim JJ, et al. *Brain* 122: 1069-83, 1999.
6. Roisson B, et al. *Brain* 126:1-15, 2003.

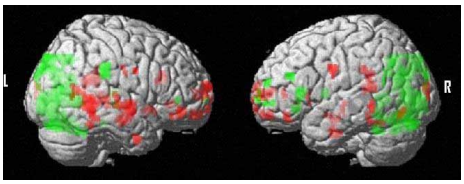

Figure 2. The activations specific to the encoding (red) and retrieval tasks (green) (paired t-test, $p < .005$).

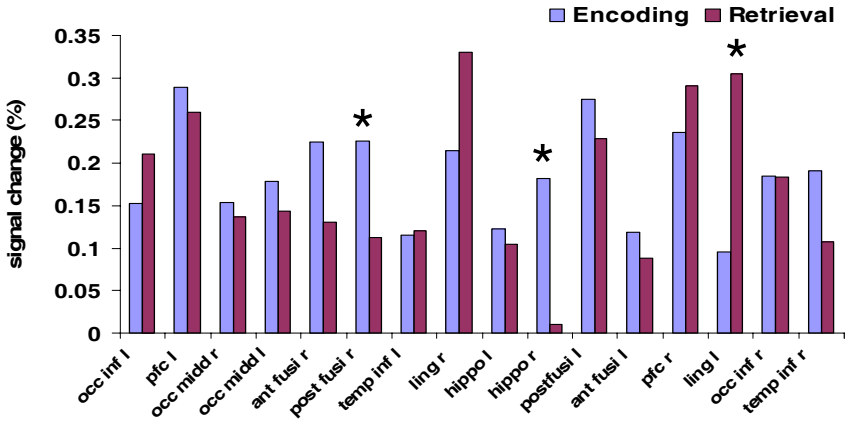

Figure 1. Comparisons of BOLD responses during encoding and retrieval tasks at 16 regions of interest in the brain. Occ, occipital; inf, inferior; l, left; pfc, prefrontal cortex; midd, middle; r, right; ant, anterior; fusi, fusiform; post, posterior; temp, temporal; ling, lingual; hippo, hippocampus.