Clinical fMRI Memory Evaluation in Pediatric Patients

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Introduction Functional MRI (fMRI) has been established as a clinically useful tool for mapping cortical areas. In particular, fMRI has proved to be a reliable tool for identifying sensory-motor cortex and localizing language. Implementing a clinical memory paradigm with robust results in individual patients has proved more challenging. Although memory has been extensively studied using fMRI, currently no established standard fMRI protocol exists for evaluating pre-surgical memory. We were interested in a paradigm that could be effectively implemented in the pediatric population. Both verbal and visual tasks have been developed that use encoding, recall or recognition paradigms. We developed a visual-spatial memory task that required individuals to visualize walking through familiar environments, a modification of the hometown walking task. We evaluated the efficacy of this paradigm for pediatric patients.

Methods We retrospectively reviewed the 9 adult controls who had been used to test the paradigm, and then identified 12 pediatric patients (age 9-17) who had been tested using this paradigm. Subjects kept their eyes closed and followed short auditory cues to minimize visual and auditory activation. A classic block-design paradigm (BABABABAB) was used with subjects switching between the Active task (mental navigation) and Baseline task (counting). Siemens (Erlangen, Germany) system, 3-Tesla (Trio) scanner was used for imaging, using 45 slice EPIBOLD sequence (TE=30ms, TR=3000ms, flip angle = 90°) with slice thickness of 3mm, no gap, voxel size 3x3x3mm. The four minute task was repeated 2 to 3 times. Analysis was performed using FSL software packages, with summation of multiple task runs. Studies were performed in the patients in conjunction with motor and language fMRI testing. Memory fMRIs were analyzed for activation in hippocampus, parahippocampus and fusiform gyri, degree of motion, results of language and motor fMRI (as an indication of cooperation). Structural scan findings and results of memory testing (when available) were also collected.

Results In control subjects, robust activation was highly reproducible and consistent with literature reports particularly of bilateral and fairly symmetric activation in hippocampal, parahippocampal and fusiform gyri (Fig 1A). Seven of 12 patients showed similar activation patterns. Two patients demonstrated more localized responses, with one of the two demonstrating mostly parahippocampal activation (Fig. 1C) and one showing only fusiform activation(Fig 1D). Three more patients had little or no detectable activation in parahippocampal and fusiform gyri; one of these was likely compromised by excessive motion, though he had performed motor and language fMRI tasks adequately.

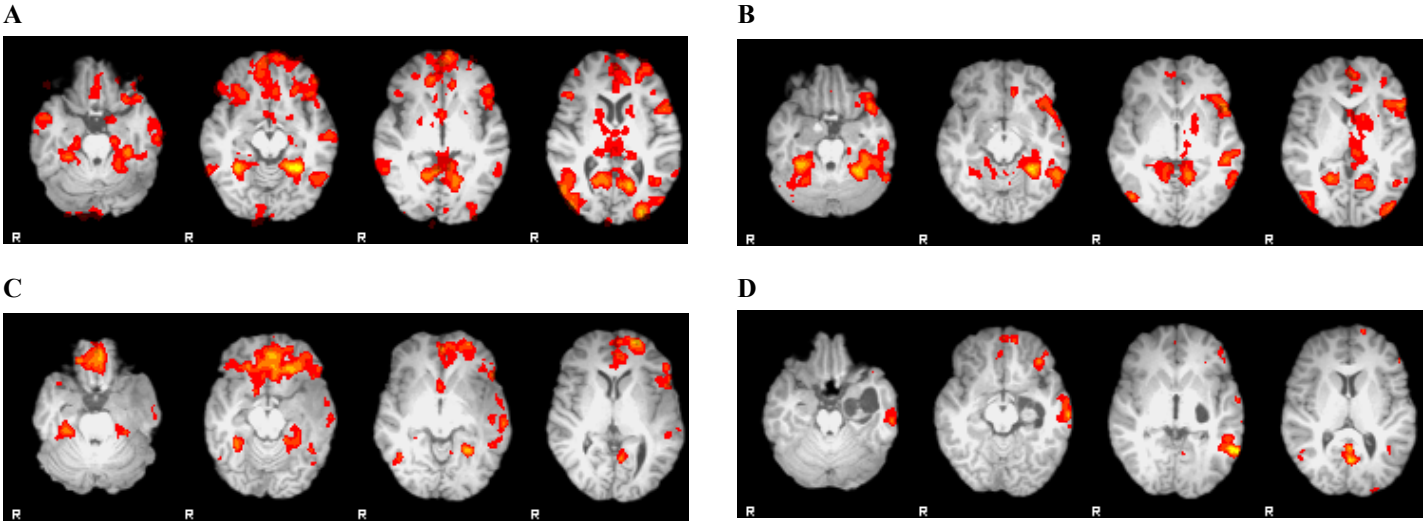

Figure 1. fMRI results on three patients and one control subject. Z statistic images were thresholded using clusters determined by Z>3.0 and a (corrected) cluster significance threshold of P=0.01. Results are shown in MNI space (Z coordinate -22, -12, -2, +8 mm). **A** Control subject, **B** Patient with a right temporal lobe tumor and lower visual (ss=88) versus verbal (ss=102) memory, **C** Patient with a left temporal tumor and poor visual (79) versus verbal (94) memory, **D** Patient with a right temporal lobe tumor and very poor visual (67) versus verbal (80) memory. ss - standard score from the Wide Range Assessment of Memory and Learning.

Conclusions These results show that this fMRI memory task is clinically viable, demonstrating expected activation in most children in a pattern similar to adult controls. The task was however not universally successful in the pediatric subjects, likely due to poor memory function/abnormal memory networks in some, but for less certain reasons in others, leaving room for further work to more universally adapt fMRI memory testing to the pediatric population.