Hidden pattern identification in fMRI: What's in the posterior parietal lobe?

R. C. D'Arcy[1], R. B. Bolster[2], L. Ryner[3], D. S. Runke[2], X. Song[1], E. Mazerolle[1]

[1]Institute for Biodiagnostics Atlantic, National Research Council, Halifax, Nova Scotia, Canada, [2]Department of Psychology, University of Winnipeg, Winnipeg, Manitoba, Canada, [3]Institute for Biodiagnostics, National Research Council, Winnipeg, Manitoba, Canada

Introduction: Embedded figures tasks are well established in neuropsychology and provide an assessment tool for visual cognitive function. The hidden visual patterns task developed by Ekstrom (1) require subjects to locate a line pattern embedded in a complex figure. These pictures are "abstract" or difficult to label, and require focused attention to perform feature identification. It has been proposed that the visual association cortex is separated into two streams and each has been found to process different aspects of visual input (2). The ventral stream projects to the inferior temporal lobes and has been associated with what an object is. This stream is thought to be primarily involved with object identification and discrimination. The dorsal stream projects to the posterior parietal lobe and is associated with the location of an object, or where an object is in space.

The current study was motivated by ongoing efforts to develop fMRI assessment measures for temporal lobe epilepsy. The hidden pattern task was expected to activate extrastriate visual cortex in the temporal lobe. We adapted this task into a match-to-sample paradigm for use in functional MRI. Discriminanda were matched to samples under two conditions: 1) hidden pattern, wherein subjects indicated whether complex patterns contained the visual target, and 2) figure location, wherein subjects indicated whether the complex pattern was located to the right or left of the target. In theory, the first condition is consistent with a 'what' task based on whether a complex pattern is present. Therefore, it was expected to generate task related activity along the ventral stream (inferior temporal cortex). Conversely, the second condition was consistent with a 'where' task, and thus was expected to generate activity along the dorsal stream (posterior parietal cortex). The strength of this paradigm is that the stimuli were equivalent in both conditions, thus differences in task-evoked regional brain activity could only be attributed to differences in task instructions (i.e., identify 'what' versus 'where').

Methods: Behavioral data and fMRI data were collected in separate experiments (Behavioural: N=24, Mean Age = 20.3, 14 females; fMRI: N=8, Mean age = 31.4, 3 females). The hidden patterns task in this study is a well-known visual perceptual task with established norms (1). The stimuli consisted of a target pattern in the centre of the screen with complex figures presented to the left or the right (Figure 1). The task was presented as a block design with two experimental conditions (hidden pattern and figure location). In the hidden pattern condition, participants indicated whether the target pattern was embedded within the complex figure (.5 probability). In the figure location condition (control), participants indicated whether the complex figure was presented to the left or right of the target. The stimulus presentation and response requirements between the two conditions were identical, with the only difference being the task instructions. The two conditions were presented in separate sessions, with 4 blocks per condition and 8 trials per block (trials: 3s durations and 1s fixation). Each block was 32s with a 16s rest period between blocks.

MRI: We used a GE 1.5T Signa LX MR scanner equipped with Echospeed actively-shielded gradient coils (22mT/m, 120mT/m/s). The functional MRI data were obtained using a single-shot gradient-recalled-echo EPI sequence with TR/TE = 2000/40ms (flip angle = 70 deg.). Whole brain imaging was performed with 24 coronal slices, 6mm thick, with a 1mm gap between slices, a 240mm FOV, and a 64x64 matrix. There were 221 volumes collected in a single session. Data preprocessing and statistics were done in SPM99. Hidden pattern and figure location factors were evaluated using t-contrast maps for group activation differences between conditions (uncorrected $p < 0.001$, Z-score > 3).

Results and Discussion: Analysis of task performance (reaction times and accuracy) revealed that hidden pattern decisions were slower ($F(1, 23) = 200.65$, $p < .0001$) and the responses were less accurate ($F(1, 23) = 26.21$, $p < .001$) than figure location decisions. These results show that pattern identification for hard-to-verbalize complex figures required more processing than simple location judgments. Figure 2 presents activation maps for the hidden pattern (top) and figure location (bottom) conditions. The results from this task were surprising. In the hidden patterns condition, bilateral activation extended dorsally from the occipital lobe into the posterior parietal lobes. The figure location condition elicited less activation, with cortical activation represented by small clusters in the temporal and frontal lobes. These results suggest that the pattern identification judgments activated the dorsal visual stream, rather than the ventral stream as predicted. Interestingly, the current results closely replicate a recent fMRI study by Manjaly et al. (3). In this study, a different set of stimuli (embedded figures) was presented, but the stimuli required the same judgment (i.e., identify a hidden target). In the control task, the figure was highlighted in order to limit activation to basic visual perceptual processing (this differs from the current control, which involved decisions about spatial location). Despite the differences in stimuli and control conditions, the hidden pattern/figure conditions revealed the same activation in both experiments (both highlighting the posterior parietal lobe). Manjaly et al. (3) concluded that the posterior parietal activation was specifically related to visual search for local target (i.e., object based visual attention). While the current results do not invalidate the what/where distinction, they highlight parietal involvement in visual attention tasks involving hierarchically organized stimuli – a pattern of cortical activation that did not map onto either the what/where dichotomy or dorsal/ventral anatomy as expected. We conclude that the parietal lobe is active when complex visual discriminations depend on 'what is where' decisions involving the attentional search of local visual features.

References:

(1) Ekstrom, 1976, Kit of Referenced Tests for Cognitive Factors, Princeton, NJ, EDS.
(2) Ungerleider & Mishkin, 1982, Analysis of Visual Behavior, Cambridge, Mass., MIT
(3) Manjaly et al, 2003, NeuroImage, **19**:674-683

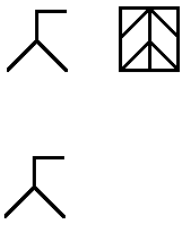

Fig. 1 Embedded figures task.
Top: hidden patterns (present) versus
Bottom: figure location (left).

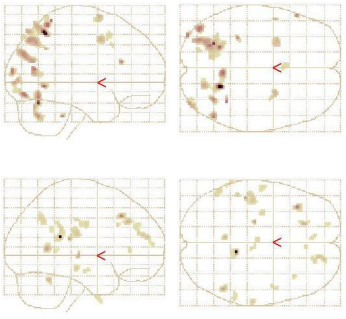

Fig. 2 Group activation maps.
Top: hidden patterns activation versus
Bottom: figure location activation