Differential neural activation in field dependent and field independent subjects for a camouflage detection task: An fMRI study

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Introduction: Since the beginning of time, man and all other types of life have used camouflage either offensively or defensively. Detecting camouflage is a 'visual search task' that requires the perceiver's ability to detect the presence of a 'target' among other elements called 'distracters' [1]. Majority of visual search studies used very simple, synthetic stimuli, in which target and distracters were easy to segment from the background. However, the real visual world is a continuous array of overlapping objects and textures that need to be segmented from the background to some degree to allow for efficient visual search [1, 2]. In the present study, we designed a paradigm to identify neural correlates for identifying camouflage in real life situations using functional MRI (fMRI). We also compared the difference in the activation pattern for field independent and field dependent subjects.

Materials and Methods: Twenty two right handed healthy individuals (9 males and 13 females, age range 18-31years, age range 18-31 years) were chosen for the study. fMRI was carried out using 3 Tesla whole-body MRI system (Magnetom Skyra, Siemens, Germany). Functional images were acquired using echo-planar T2*-weighted sequence. Each brain volume consisted of 36 interleaved 3 mm thick slices with 0.6 mm interslice gap and parallel to AC-PC axis (TE = 36 ms; TR = 3000 ms; FOV = 220 mm; flip angle = 90°; voxel size = 3.3 X 3.3 X 3 mm). Block paradigm (B1B2AB1B2AB1B2A….) with alternating phases of activation (A) and two baselines (B1 and B2) was chosen. 174 sequential image volumes (belonging to five cycles + one baseline for eliminating T1 saturation effects and acclimatization of the patient to the gradient noise) were taken. In the activation phase, each block consisted of 7 real life photographs out of which 5 photographs had camouflage and 2 had no camouflage in them. Subjects' task was to view the photographs and identify if they have camouflage or not and if so in which part of the picture it lies. Camouflage pictures used were standardized on a 5 point difficulty scale; 5 being most difficult and 1 being least; by 16 individuals; of which 8 were previously exposed to camouflage and other 8 were non-exposed individuals. Pictures with mean rating 2.67 and above were used in the active phase. Baseline 1 consisted of 5 non camouflaged natural pictures. Subject had to just view those photographs. Baseline 2 consisted of 7 photographs with a lower order camouflage with difficulty level less than 1.5. Each photograph was presented for 3 seconds after which 2 seconds were given to the subject to give the response. Stimuli were presented using fMRI hardware from NordicNeuroLab http://www.nordicneurolab.com/Products_and_Solutions/nordic_fMRI_solution/index.aspx) while the subject's response was recorded with the help of a 4 button response grip. Prior to the scanning session Witkin's embedded figure test was used to classify the subjects as field-dependent or field-independent. They were also asked to perform the task after the scanning session to note their offline response. Pre- and post-processing of the functional MRI scans were performed using SPM8. A one-sample t-test ($p<0.001$ (uncorrected), 20 voxels) for group analysis was performed for Active phase minus Baseline 1 (AmB1) and Baseline 2 minus Baseline 1 (B2mB1) conditions in both field independent and dependent groups (each group had 11 subjects). To find the difference in the BOLD activation pattern among the two groups for the two conditions, a 2-sample-t-test ($p < 0.05$ uncorrected, 90 voxels) was carried out. The anatomical representation of the clusters was related to cytoarchitectonic maps as implemented in the SPM Anatomy Toolbox [3].

Results and Discussion: Descriptive statistics for offline scores are as follows: Field dependent subjects = 22.82 $\pm$ 4.94; Field independent subjects = 26.45 $\pm$ 5.78. No statistically significant correlation was found between accuracy of task performance and witkin's score (females: ($r= -0.454$; $p > 0.05$); males: ($r= -0.407$; $p > 0.05$). Clusters of activation obtained in the two conditions for the two groups are given in Table 1 and 2. All the regions activated have been implicated in visual selection and discrimination, visual attention, visuospatial processing, categorical processing of the stimulus etc [4, 5, 6, 7]. Greater clusters of activation in the field dependent subjects than the independent ones in most of the activated regions suggest more effort required by them for task performance. Direct comparison of the two groups for the two conditions using a 2-sample-t-test revealed that for both the conditions field dependent subjects activated more of visual selection area (right inferior occipital gyrus, Area V4) than field dependent subjects but field independent subjects activated more of ascending reticular activation system involving thalamus, and other attention and visuo-spatial processing areas like superior parietal lobule and cerebellum than the field dependent subjects, which might explain the better task performance by the field independent subjects.

Conclusion: Initial results suggest that a widespread activation of brain networks is required by the field dependent subjects as compared to the field independent ones for a camouflage detection task. However, recruitment of additional superior parietal, thalamic and cerebellar regions might serve to better coordinate this processing in field dependent subjects who experience their surroundings analytically, without the influence of contextual field.

References:

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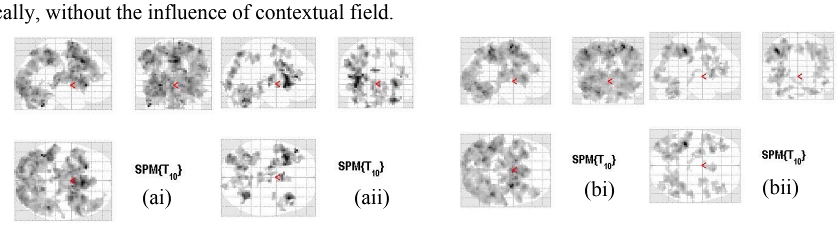

Figure 1: Glass brain view showing clusters of activation for (a) AmB1 and (b) B2mB1 in (i) Field dependent subjects and (ii) Field independent subjects

Table 1: Clusters of activation for AmB1

Clusters of activation (Location of peak voxels)	Cluster count	
	Field Dependent	Field Independent
Cerebellum	4648	1024
Right Post Central Gyrus		
Left Inferior Parietal Lobule		
Left Superior Parietal Lobule		
Left Inferior Occipital Gyrus		
Left Area 6	4126	174
Right Area 6		
Left Inferior Frontal Gyrus (Area 44/ 45)	0	816
Thalamus		
Right Inferior Frontal Gyrus (Area 44/ 45)	0	209

Table 2: Clusters of activation for B2mB1

Clusters of activation (Location of peak voxels)	Cluster count	
	Field Dependent	Field Independent
Cerebellum	9534	1330
Right Post Central Gyrus		
Left Inferior Parietal Lobule		
Left Superior Parietal Lobule		
Left Inferior Occipital Gyrus		
Left Area 6		
Right Area 6		
Inferior Frontal Gyrus (Area 44/ 45)	961	861
Right Post Central Gyrus	0	503
Right Inferior Parietal Lobule		
Right Superior Parietal Lobule		