Neural mechanisms of top-down control during visual search: Effects of template complexity

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Introduction

- Current models propose that visual search is a process of biased competition controlled by an internal template describing the target to be sought . When the display is processed, matching against this template guides attention to the target [1].
- Template matching may require more resources when the target is a conjunction of two features (such as colour and shape) rather than a single feature (i.e., colour) [1-2].
- Previous fMRI studies have investigated the differential neural correlates of target processing for feature vs. conjunction visual-search displays [2]. However, no studies to-date have specifically addressed top-down processes at play during visual search.

Aims

- To explicitally separate the neural correlates of *"Template preparation"* from those of *"Visual Search"* using a fast-rate event-related fMRI paradigm [3].
- To assess the effects of Template Complexity (Feature vs Conjunction) on both Visual Search [2] and Template Preparation.

Methods

Subjects- 15 metal-free healthy participants (22-49 ys, 1 L-handed), normal vision.

Stimuli- A modified Visual Search Task using Feature and Conjunction displays [1-2]. A Cue and a Template Cue preceded the Target display (see Fig.1). All displays contained 32 items.

Practice- A 45-min session outside the scanner, to assess/reach adequate perfomance (>80% Hits), and learn to avoid eye-movements.

MRI Acquisition- Echo-planar images collected on a Philips Gyroscan Intera 3T scanner, equipped with a SENSE coil. Gradient echo sequence: TR/TE 2000/30 ms, 90º flip angle, FOV 216x143x240mm, 3mm slice thickness, slice gap 1mm, 36 axial slices.

MRI Analysis- SPM2 software [4] was used for image reorientation, realignment, normalization into MNI space, and smoothing (8mm FWHM). Event-related responses to Passive, Attend-Cue and Attend-Cue+Target trials were modelled with a synthetic hemodynamic response function. For each subject, contrast images were computed (fixed-effect model). The images were entered in random-effect analyses to assess significance across subjects (p<.01, T>8.66, corrected). To further assess *Template preparation* effects, ROIs were derived from Visual Search effects, and One-within ANOVAs were used to test significant differences. Post-hoc comparisons used Bonferroni correction (p<.05, 2-tailed).

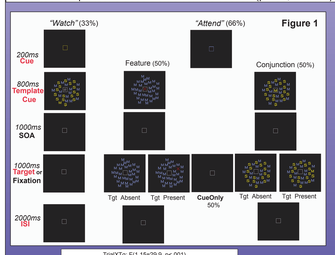

Figure 1

Figure 2- Behavioral findings

RT results- There was a significant Template Complexity X Pres/Abs interaction, with Target Absent RTs longer than Target Present RTs, but more so for Conjunction Search trials (Figure 2).

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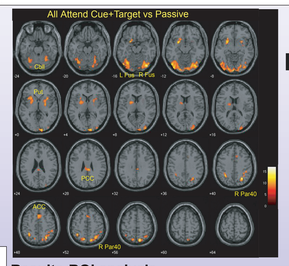
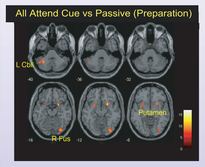
Results-SPM (p<.01, corrected).

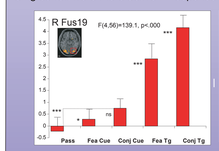
- ***All Attend Cue+Target vs Passive***- Activations included bilateral fusiform gyri 19, bilateral inferior parietal lobule 40 (R>L). Ant and Post Cingulate cortex, R DLPFC46, bilateral putamen and lateral cerebellum.
- ***All Attend Cue Only vs Passive***- Activations included R fusiform gyrus 19, bilateral putamen (R>L) and left lateral cerebellum.

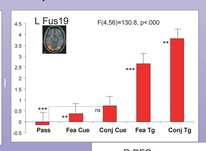


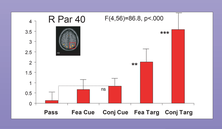


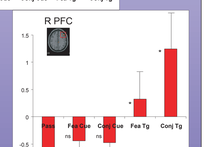
Results-ROI analysis- (p<.05 corrected)

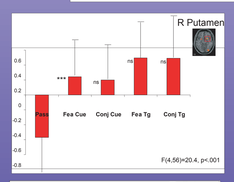
- ***All Attend Cue Only vs Passive (i.e, Preparation)***- Significant BOLD signal changes were also found in L Fusiform gyrus19, R parietal 40, and Ant Cing Cortex. No significant change was present in R DLPFC. Such effects were stronger for Conjunction than Feature Cues in bilateral Fusiform gyri and R parietal cortex.
- ***Conjunction vs Feature Cues***- Conjunction Cues vs Feature Cues did not differ from one another in any region.
- ***Conjunctions vs Feature Targets***- Bilateral Fusiform gyri, R parietal cortex, R PFC46 and Ant Cing cortex were more active in response to Conjunction than Feature search

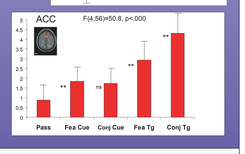


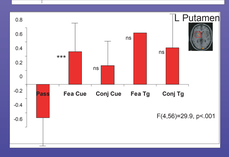












Conclusion- Template Preparation during visual search activates, albeit at a lesser degree, several of the same brain areas involved in Visual Search (R Par40, Fusiform gyri, ACC). In addition, unique activations in bilat Putamen and L Cbll suggest a role for these structures in top-down aspects of attentional control.

References

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