Neural Correlates of Holistic and Configural Visual Object Processing

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Introduction

Visual system utilizes distinct modes of visual processing[1,2] based on level of information; mediated by activity in unique brain areas

- Holistic: Global shape, outlines, Gestalt; lateral occipital cortex (LOC)[3,4]
- Configural: Local features, details, parts; intraparietal sulcus (IPS)[5,6]

Number of visual parts present within a stimulus influences the type of processing used[5]

- Fewer parts = more holistic
- Many parts = more configural

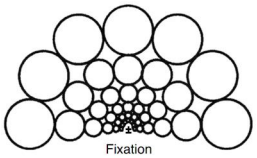
Visual stimuli may not be perceived strictly by one process alone[7]

Visual Crowding: naturally occurring effect that disrupts recognition of closely-spaced objects presented in the peripheral field[8,9]

- Crowding also occurs within objects such that those with more component parts experience more crowding and vice versa[7,8]

Critical Spacing: minimum amount of distance necessary to distinguish amongst unique objects/shapes at various locations in the peripheral field[7]

Isolation field: region described by a perimeter of minimum critical spacing around an object. Varies in size according to distance from fixation[8]



Hypotheses

1. Holistic objects expected to elicit activation in LOC and ventral occipito-temporal (VOT) stream
2. Configural objects expected to correlate with parietal lobe (IPS) activity
3. Effects of holistic and configural processing may be lateralized (left → parts-based; right → global shape)

Method

Stimuli

- Bank of Standardized Stimuli (BOSS)[10]
- High-resolution photographs of real-world objects
- Includes normalized data with ratings of semantic and higher-level visual properties (e.g., familiarity, category, complexity)

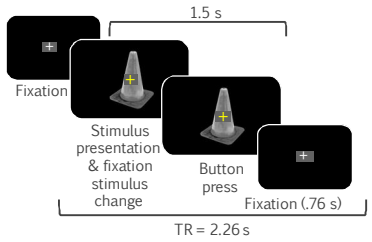
Preprocessing

- 27 images with frontal-parallel viewpoint
- Converted to grayscale
- Normalized for contrast and luminance using SHINE toolbox[11]

Tasks presented using MATLAB and Psychophysics Toolbox

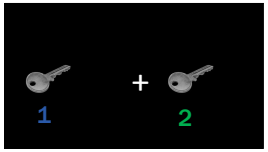
Neuroimaging Task

- 17 participants (9 female, 8 male)
- Objects presented at fixation (TR = 2.26 s)
- Visual angle = 4.29°
- Index 1, Type 1 fast event-related design[12]
- 785 trials
- Button press recorded at beginning of TR (fixation stimulus changed color)



Behavioral Task

- 20 participants (9 female, 11 male)
- Visual angle = 7.33°
- Labels entered for all objects
- Used chinrest, fixated cross at center of black screen
- 1. Object presented briefly at various distances in peripheral field on left or right side of screen (150 ms)
- Images identified aloud; coded for accuracy in real-time by experimenter
- Max. eccentricity = 31.02°
- 2. Incorrect: Image moved 75 px (3.7°) closer to fixation when it next appeared on same side of screen
- Correct: Location on screen recorded as critical eccentricity
- Objects correctly identified on both sides of screen before being removed from the set

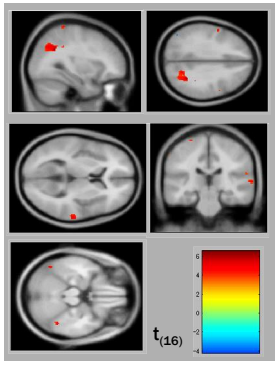


Results

Neuroimaging

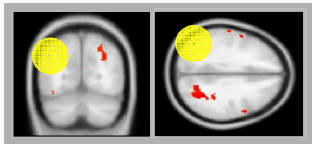
Holistic

- R parietal [x=32, y= -56, z=32; cluster=431; t(16)=6.561, p<.001]
- R Superior temporal gyrus [x=66, y= -26, z=6; cluster=37; t(16)=4.7706, p<.001]
- Bilateral fusiform gyrus [x=48, y= -50, z= -22; cluster=13; t(16)=4.1643, p<.001]



Configural

- Left angular gyrus [x= -44, y= -70, z=36; cluster=13; t(16)= -3.9686, p<.001]



Behavioral

Familiarity ratings [B= -116.161, t(43)= -2.909, p=0.0057], object agreement [B= 64.540, t(43)=2.432, p=0.0193] significantly correlated with behavioral critical eccentricity

Discussion

Behavioral

Familiarity inversely correlated with critical eccentricity

Object agreement positively correlated, but substantively related to familiarity

- Possible minimum eccentricity limit for accurately indexing parts-based processing

Neuroimaging

Hyp. 1 & 2 partially supported (anterior VOT)

- FFA activation may suggest connection between holistic object & face perception[13]

Hemispheric lateralization (Hyp. 3) suggested in neuroimaging, but not behavioral data

- Behavioral effects more likely in tasks with attentional conflict and hierarchical stimuli[14]

Limitations

- Not enough significant configural ROI's to confidently support predictions
- Configural activation not found within IPS
- Contrast restricted to mutually exclusive activation
- Possible effects of hemispheric competition & transcallosal inhibition

Future directions

Analyze the effects of normative ratings on neural activation

- Redefine cut-off for holistic vs. configural & reanalyze data

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