Concurrent fMRI analysis of part-whole structure and subjective object norms for items from the BOSS (Bank of Standardized Stimuli) data set

VirginiaTech Invent the Future

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Introduction

Visual system can utilize distinct modes of visual processing[1,2] for different objects

- **Holistic:** Global shape, outlines, Gestalt; lateral occipital cortex (LOC)[3,4]
- **Configural/Analytic:** Local features, details, parts; perhaps 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]

The BOSS : Assessments of holistic/analytic modes will make more sense in the context of the covariance structure of the many possible object features.

- The BOSS dataset includes normative ratings of numerous high-level features, which can complement analyses based on local image features.

Oblimin rotated exploratory factor analysis

	Factor		
	1	2	3
Familiarity	.995		
Category agreement			
Visual complexity			
Object agreement		.904	
Viewpoint agreement		.656	
Manipulability			.747
Name agreement			.323

Goals

1. Identify cortical regions associated with crowding-based behavioral measure
2. Identify cortical regions correlated with key BOSS ratings
3. Assess the correlation of the crowding-based measure with BOSS ratings

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)

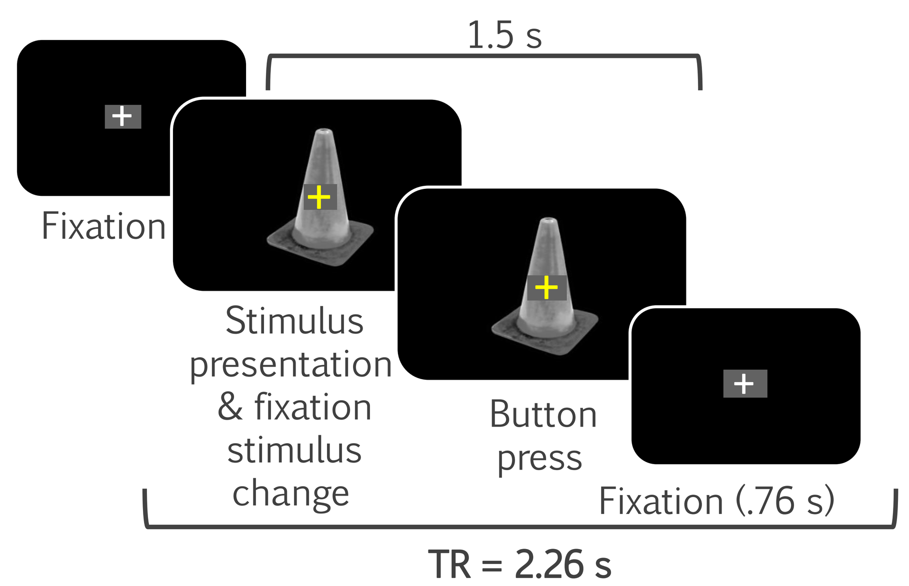
Preprocessing

- **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

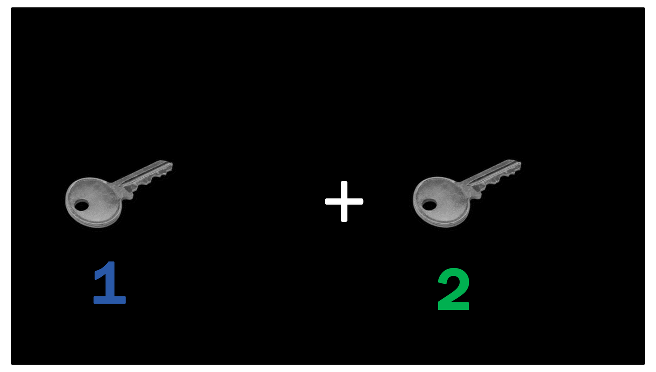
Neuroimaging Task

- 16 participants (9 female, 7 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

- Same participants, post-scan
- 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

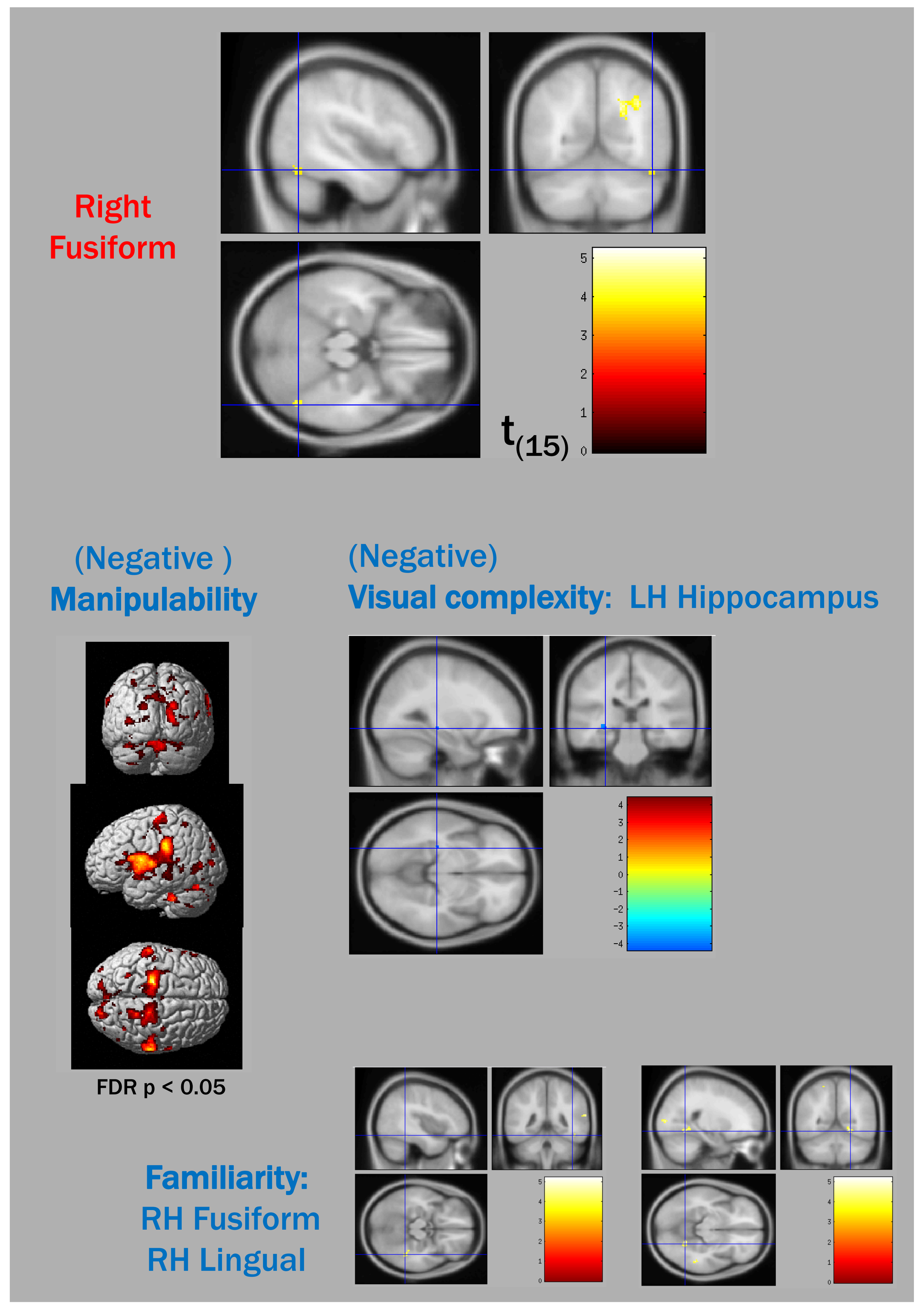
Neuroimaging

Crowding Measure

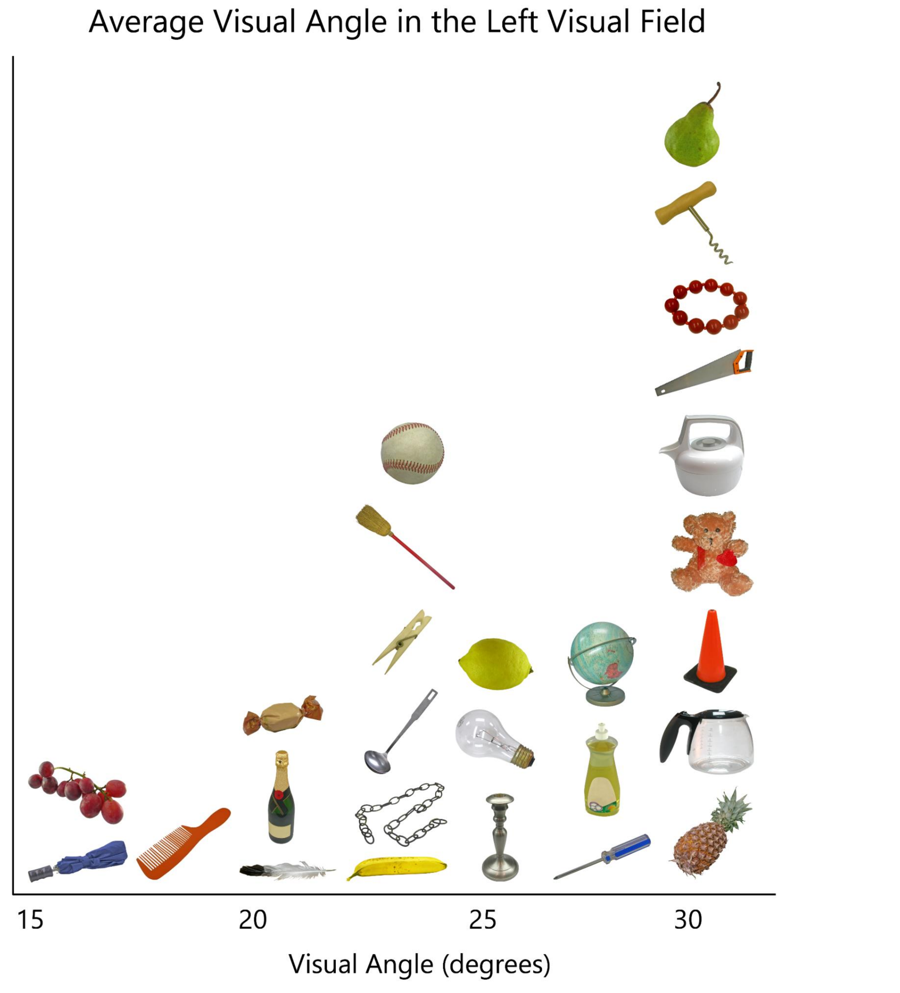
- **Model:** beta weights for each of the 27 objects
- **Contrast:** proportional to each participant's critical eccentricity scores

BOSS Norms

- **Model:** parametric modulations (SPM8) for familiarity, visual complexity, viewpoint agreement & manipulability
- **Contrast:** betas vs. baseline
- **Reduced model:** no manipulability
- Effect of familiarity found



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

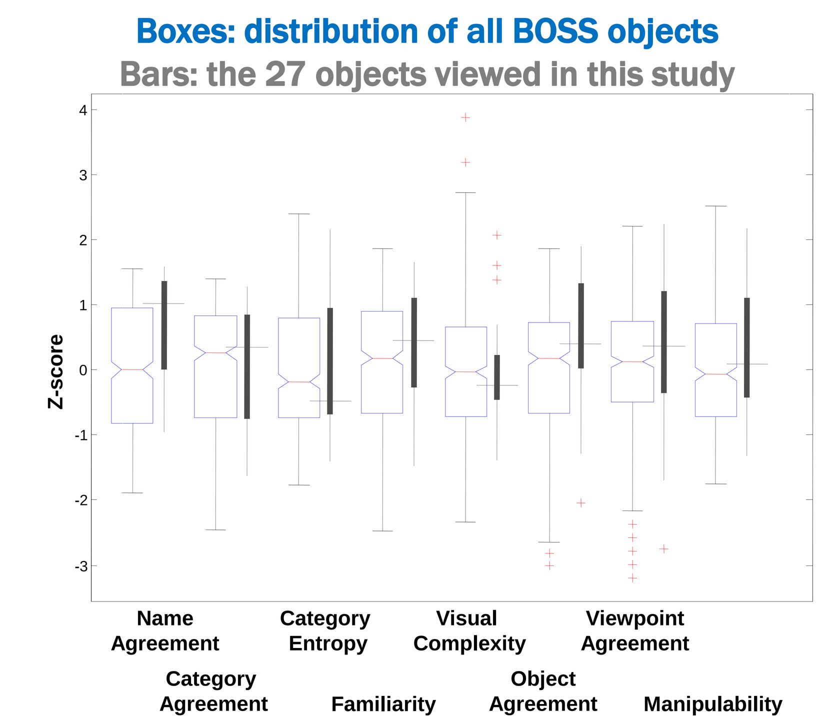
Discussion

Behavioral

Familiarity inversely correlated with critical eccentricity

Limitations

- Critical eccentricity contrast restricted to mutually exclusive activation, i.e. betas reflect correlation with entire range
- Small number of items compared to total BOSS (27), although represenative sample:



Future directions

- Hemisphere effects
- Principal components regressions

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