Greater Sensitivity to Categorical than Metric Differences in Relations

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Background

Behavioral studies and single cell recordings in monkey IT have shown that there is greater sensitivity to changes in singular properties (e.g., straight or zero curvature), than non-singular properties (e.g., curved versus more curved) of simple shapes (Biederman et al., 2009; Kayaert et al., 2003).

Are we similarly more sensitive to singular (i.e., categorical) than non-singular (i.e., metric) differences in the relations between objects?

Categorical (CAT) versus metric (MET) variations in relations between two objects

Δ CAT Δ Metric

Different Kinds of Relations

Alignment

Attachment

Occlusion

Control for physical dissimilarities between CAT and MET

Critically both relational variations were matched in physical dissimilarity by pixel energy and the Gabor-jet model. (Lades et al., 1993)

Adaptive staircase match-to-sample task (QUEST)

CAT Trial MET Trial

A to-be-matched stimulus (top) was presented with two samples (bottom), one of which was an identical match and the other, a distractor that varied in either a CAT or MET relational change.

To encourage subjects to understand the structure of the object pairs (rather than relying on a point-by-point matching) the to-be-matched stimulus and samples were rotated in opposite directions by 40°.

Presentation Duration Δ (MET-CAT) Duration

To achieve 75% accuracy, subjects required more than double the amount of presentation duration for detecting differences in MET (795 ms) than CAT (330ms) relations.

fMRI Experiment

Each trial consisted of two images flipping from BASE => CAT/MET or translating (~0.5° for BASE condition only). Subjects detected if the two objects were moving in the same (BASE) or different (CAT and MET) directions.

ROI Analysis

ROIs: LO was the only region showing greater BOLD responses to CAT than MET changes. MVPA did not reveal any differences in patterns of activation for CAT and MET changes.

Conclusions

• Consistent with the findings of simple shapes, there is greater behavioral sensitivity to changes in singular (CAT) than non-singular (MET) changes in relations between objects.
• The larger BOLD response in LO for CAT suggests that LO might be the neural correlate for the advantage of CAT change detectability.
• MVPA results suggest that sensitivity of CAT and MET changes can not be distinguished (i.e. they are not independent).