

Do Eye Movements Incorporate Knowledge of Part Structure?

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INTRODUCTION

What strategies underlie eye movements?

In our previous work with novel shape silhouettes, we introduced an information theoretic approach for probing eye movement strategies¹⁻⁴. Here we examine whether our perception of parts in the task can provide a better explanation of observed fixations.

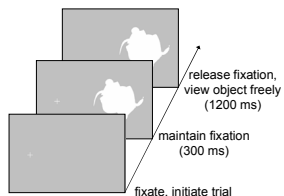
HYPOTHESIS

Perceived parts are used to plan eye movements

EYE MOVEMENT TASK

Learning

Subjects study a novel shape while their eye movements are recorded.



Discrimination

Subjects rate their confidence that the top or bottom shape is a match.



- **Learning:** shapes are centered at 10 degrees left or right of fixation and subtend 12.5 degrees; 120 novel shape pairs were used
- **Discrimination:** observers rate response as "confident" or "guess"; feedback was provided
- **Method:** observer's head was positioned with a bitebar and measurements were made with an SRI Dual Purkinje Image eye movement monitor

MODELING INFORMATION

PRIOR KNOWLEDGE

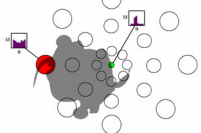
Information at an edge point is represented by a probability distribution over orientation



We describe the distribution by its **ENTROPY**

$$H = -\sum_{\theta} p_{\theta} \log_2 p_{\theta}$$

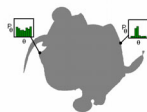
MEASUREMENT



The eccentricity E of an edge point from fixation determines how many of its neighbors will be processed in the same perceptual hypercolumn in the cortex⁵.

Neighbors fall within radius $r = s(E + E_2)$ with $s = 0.1$ and $E_2 = 0.8$

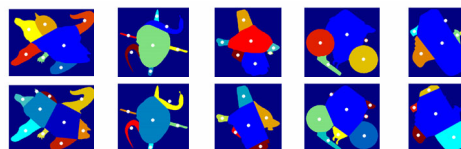
UPDATE KNOWLEDGE



Uncertainty about the orientation of the contour points (entropy) changes as fixation moves and knowledge is updated. Entropy can be computed for the whole object or for individual parts.

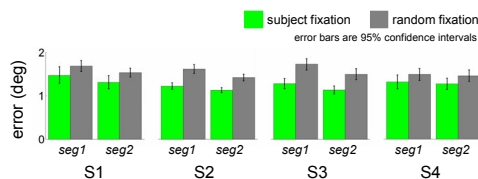


FIXATING PART CENTROIDS



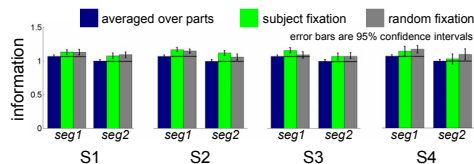
Observers segmented objects into parts using a custom manual segmentation tool. The centroids of parts are marked⁶.

AVERAGE FIXATIONAL ERROR



Observers' fixations are ~1.4 deg from the nearest part centroid, which is significantly closer than a "smart" random model.

DO WE FIXATE INFORMATIVE PARTS?



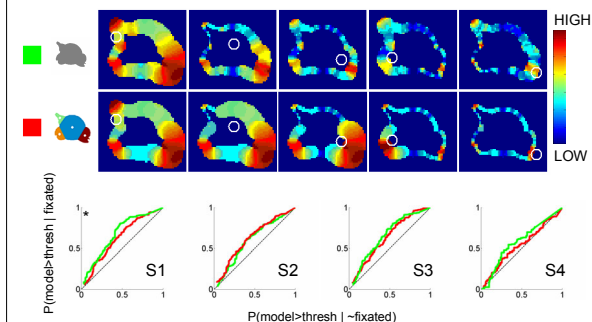
The parts fixated by observers are *more* informative on average, and may be mostly explained by their overall fixation distribution.

references

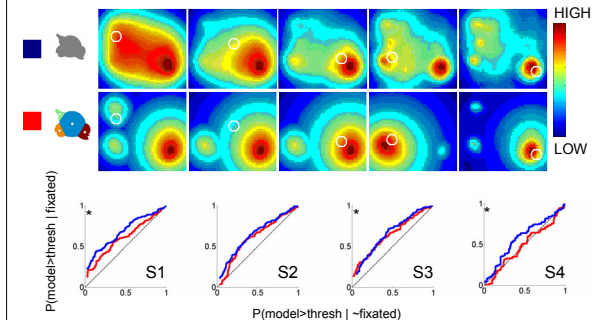
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PREDICTING FIXATIONS

LOCAL UNCERTAINTY



MAXIMIZE TOTAL INFORMATION



Reducing local uncertainty is often the best predictor of human fixations in this shape learning task⁸. Adding a part representation does not boost prediction performance. Maximizing total information (the optimal strategy) in a part-wise manner reduces prediction performance.

CONCLUSION

Perceived parts may not be required for eye movement planning

Edges may be enough!