The Spatial Distribution of Object-based Attention

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Introduction

Attention operates not only over spatial locations but also over perceptual objects. One of the hallmarks of object-based attention is that following an invalid peripheral cue, perceptual judgments are more efficient when the target appears in the same object as the cue versus in a different object (e.g., Egly et al., 1994). However, the manner in which attention is oriented to and within objects is not well understood.

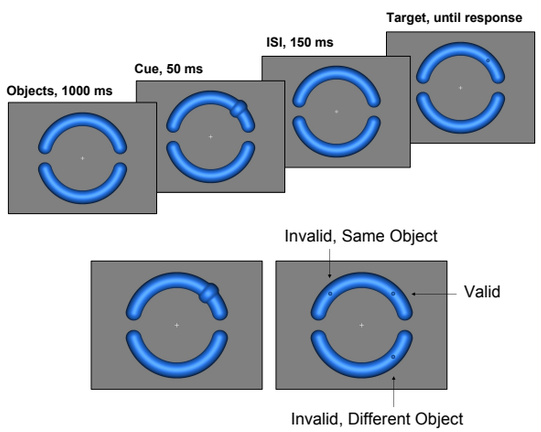
We investigated a core issue in object-based selection: the spatial distribution of attention within and across objects. The method built upon the Egly et al. paradigm. We first replicated the same-object advantage in that paradigm. To examine the spatial distribution of attention within and across objects, we added a manipulation of within-object distance between cue and target. Evidence of spatial distance effects within objects would suggest that object-based selection is inherently spatial, consistent with grouped-array theories (Vecera, 1994) in which object perceptual structure is proposed to constrain the spatial distribution of attention.

Experiment 1: Replication of Egly et al. (1994)

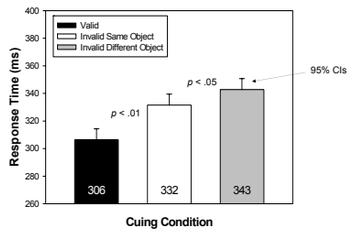
Before examining within-object distance effects in object-based attention, we first sought to replicate the Egly et al. effect using more realistic, three-dimensional stimuli. Two curved, "tube" objects were used so that all points on each object were equally distant from fixation. Cues and targets were intrinsic properties of the objects themselves. The cue was a "bulge" on one end of an object that grew and receded over 50 ms. The target was a "bump" that grew out of the object over 30 ms.

On each trial, an onset target (the "bump") appeared at one of three possible locations relative to the cue: at the cued location (*valid* condition, 63% of trials), at an invalid location within the cued object (*invalid, same object* condition, 10% of trials), or at an invalid location in a different object (*invalid, different object* condition, 10% of trials). No-target catch trials constituted the remaining 17% of trials.

Experiment 1: Method



Experiment 1: Results



Exp. 1 replicated Egly et al. (1994).

RT: Valid < Invalid Same Object < Invalid Different Object

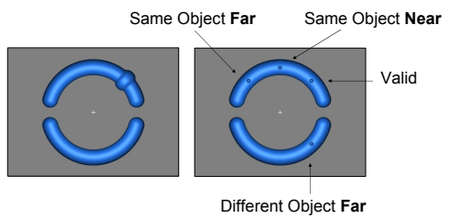
Catch Trial Accuracy: 95.2%

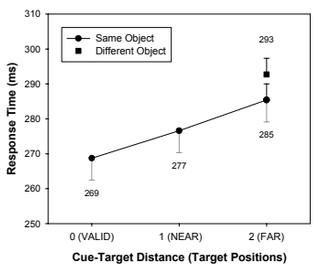
Experiment 2: Within-Object Distance

In Exp. 2, we examined the spatial distribution of attention within and across objects by manipulating same/different object and within-object distance. Simple detection efficiency of the "bump" onset was used as a measure of the spatial distribution of attention following the cue. This experiment was similar to Exp. 1 with the addition of the within-object distance manipulation.

On each trial, the onset target (the "bump") appeared at one of four possible locations: at the cued location (*valid* condition, 58% of trials), at a near location within the cued object (*same object near* condition, 8% of trials), at a far location within the cued object (*same object far* condition, 8% of trials), or at the far location in the other object (*different object far* condition, 8% of trials). No-target catch trials constituted the remaining 18% of trials.

Experiment 2: Method and Results





Experiment 2: Results Summary

Reliable effect of within-object distance, $p < .005$

Reliable effect of same/different object ($p < .05$), replicating Exp. 1.

Catch Trial Accuracy: 92.9%

Experiment 3a: Full Ring Distance Manipulation

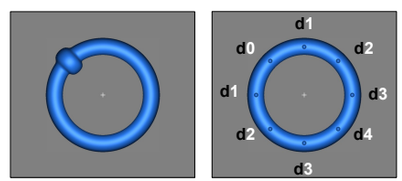
In Exp. 2, within-object distance was confounded with absolute location. In addition, far locations were closer to edges of the tubes than were near locations.

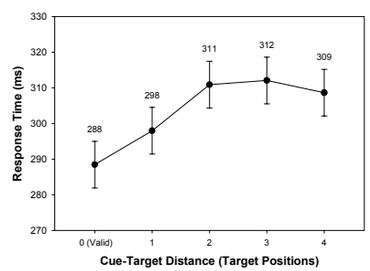
In Exp. 3, within-object distance between cue and target was manipulated while controlling absolute position and target proximity to the object edge.

A single ring was used. The onset target appeared at the cued location on 50% of trials (*valid* condition). Invalid targets were equally likely to appear at one of the remaining 7 target locations (32% of trials). No-target catch trials constituted the remaining 18% of trials.

Cue-target distance was either 0 (valid), 1, 2, 3, or 4 target positions.

Experiment 3a: Method and Results





Reliable effect of within-object distance ($p < .001$), replicating Exp. 2.

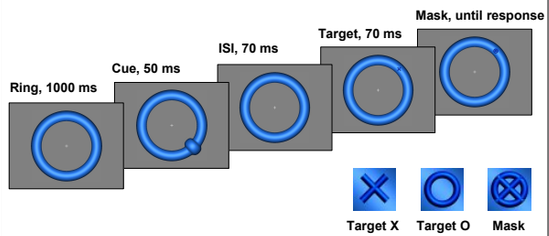
Catch Trial Accuracy: 94.1%

Experiment 3b: Full Ring, Masked Discrimination

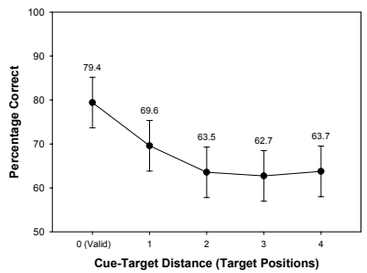
Effects on RT in Exps. 1, 2, and 3a could have been due to differences in bias rather than to differences in the efficiency of perceptual processing.

To eliminate possible effects of bias, Exp. 3b replicated Exp. 3a but with a masked discrimination task. Accuracy was the dependent measure.

Experiment 3b: Method and Results



Single mask eliminates position uncertainty (Henderson, 1996).



Reliable effect of within-object distance, $p < .005$.

Accuracy in Exp. 3b closely replicated the RT pattern in Exp. 3a.

Conclusions

Object-based attention was inherently spatial. We observed a spatial gradient across the attended object, consistent with gradient theories of attention (Laberge & Brown, 1989) and with spatial cuing studies examining cue-target distance effects (Henderson & MacQuistan, 1993).

In addition, the spatial profile of attention was sensitive to object boundaries (Exps. 1 and 2), suggesting that object-based effects are caused by differences in the spatial distribution of attention within and across objects. (This does not eliminate the possibility of space-invariant selection under different conditions, however.)

The results of the Exp. 3b discrimination task confirmed that the effect of attention in these experiments was on the efficiency of perceptual processing.

This study supports grouped-array theories of object-based attention (Vecera, 1994), illuminating how objects serve to constrain spatial selection.

References

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