The Role of Object Discontinuity in Object-based Selection

Ashleigh M. Richard, Shaun P. Vecera, & Andrew Hollingworth
Department of Psychology, University of Iowa

J58

Introduction

There are at least two hypotheses of how attention is directed to objects and object-based effects are generated: (1) The effect of objects on attentional selection is due to a cost associated with either dividing or switching attention between discrete object representations (Egly et al., 1994; Lamy & Egeth, 2000) (2) Object effects arise because the spread of attention is constrained by object boundaries (grouped array hypothesis, Vecera, 1994). Critically, the former hypothesis requires two separate object representations for object-based effects to emerge, while the latter requires only object discontinuity or a disruption in object boundaries.

In the present study, we examined whether local object discontinuity (i.e., a gap) can account for object effects in a target discrimination task. Displays consisted of one object with a gap or two objects, separated by two gaps rather than one. If the magnitude of the object effect (i.e., the decrement in target discrimination performance when the target appeared across the gap) is the same across a gap dividing one and two objects, these results would suggest that local discontinuity is the primary cause of object-based effects, consistent with the grouped-array hypothesis.

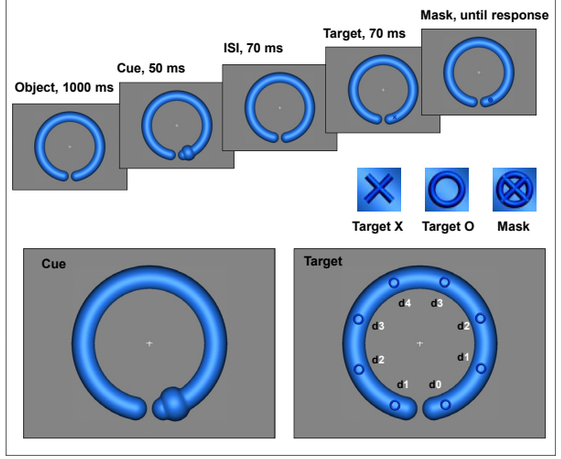
Experiment 1: Effects of Local Discontinuity

To test these opposing hypotheses, participants were presented with a curved "horseshoe" object with a single gap. Target discrimination was tested following a cue for locations both along the object and across the gap. Under these circumstances, the Egly et al. view predicts that there should be no difference between target discrimination at locations equally distant from the cue because there is no need to divide or switch attention between objects. There is only one visible object. However, the grouped array hypothesis predicts that target discrimination will be more accurate at locations along the object relative to equidistant locations across the gap. This is because the object boundary created by the gap will constrain the distribution of attention, retarding the spread of attention across the gap.

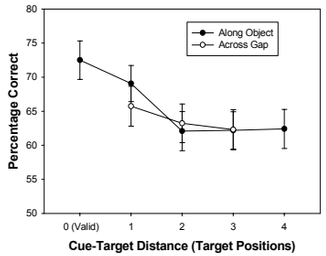
Cues and targets were intrinsic properties of the object. The cue was a "bulge" on one end of an object that grew and receded over 50 ms. The target was an "X" or "O" that appeared as part of the object, followed by a mask consisting of both targets superimposed. The discrimination target appeared at the cued location on 36.4% of trials (*valid* condition). Invalid targets were equally likely to appear at one of the remaining 7 target locations (63.6% of trials). Absolute location of the gap was counterbalanced across trials. Cue-target distance was either 0 (valid), 1, 2, 3, or 4 target positions. The cue could appear in four possible locations. Two cue locations were on either side of the gap (see figure). Two additional cue locations were in the middle of the object, opposite the gap. The latter cue locations were included so that participants would not pre-focus attention on the gap region.

Before examining effects of object discontinuity, we ran a control experiment (N=12) to ensure that there was no lateral masking of targets near the ends of the objects. In this experiment, there was no cue, and the targets were equally likely to appear at each of the eight target positions. Discrimination performance for targets at the ends of objects (75.4%) was no worse than at other positions along the object (75.5%) $F<1$. Thus, lateral masking could not account for performance differences in the present study.

Experiment 1: Method



Experiment 1: Results



For positions 1, 2, and 3, there was a reliable effect of distance along the object [$F(2,48) = 11.6$, $p < .001$] but no effect of distance across the gap [$F(2,48) = 1.81$, $p = .174$]. In addition, accuracy at position 1 was higher along the object than across the gap [$F(1,24) = 5.31$, $p = .030$].

The results were consistent with the prediction of the grouped-array hypothesis. Significant effects of object discontinuity were observed despite the fact that only one object was displayed.

Experiment 2: Across Gap -- One vs. Two Objects

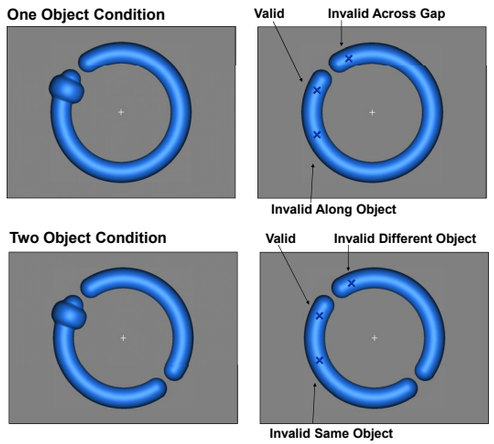
Experiment 1 found significant effects of object perceptual structure on target discrimination with one object, suggesting that results previously attributed to shifting or dividing attention between object representations might instead be caused by local object discontinuity. To determine whether local discontinuity accounts for the entire object-based effect in this paradigm, Experiment 2 included both a one-object condition and a two-object condition.

Under these circumstances, the Egly et al. view predicts that the two object condition will exhibit greater costs in discrimination performance across the gap because attention must switch between two separate object representations.

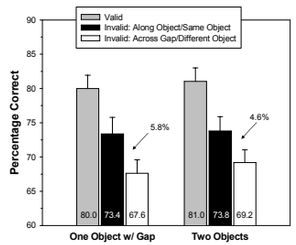
However, according to the grouped array hypothesis, the local discontinuity along the object is responsible for traditional object-based effects by interrupting the spread of attention, regardless of the number of objects. Therefore it predicts that target discrimination will be equally affected by the gap in both the one and two-object conditions.

Experiment 2 was similar to Experiment 1 with the following exceptions. Half the trials consisted of one object displays and half the trials consisted of two object displays. On each trial, the discrimination target (the "X" or "O") appeared at one of three possible locations: at the cued location (*valid* condition, 67% of trials) or at one of the two other invalidly cued locations (*invalid* across gap/ different object and *invalid* along object/ same object, 33% of trials).

Experiment 2: Method



Experiment 2: Results



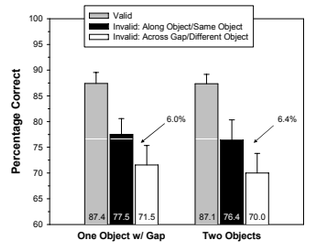
There was a main effect of gap for invalid cues [$F(1,29) = 22.3$, $p < .001$], replicating Experiment 1. And the size of the effect did not differ between the one-object (5.8%) and two-object (4.6%) conditions, $F < 1$.

These results demonstrate that local discontinuity accounts for the entire object-based effect in this paradigm.

Experiment 3: One vs. Two Object Control

Experiment 3 was conducted to ensure that participants were indeed perceiving either one object or two objects in the display. The method was identical to Experiment 2, except participants were required to respond at the beginning of each trial whether the display consisted of one object or two objects. The data report, below, includes only trials on which the participants correctly reported the number of objects in the display (mean accuracy = 99.1%).

Experiment 3: Results



There was a main effect of gap for invalid cues [$F(1,9) = 9.81$ $p < .05$], and the size of the effect did not differ between the one-object (6.0%) and two-object (6.4%) conditions, $F < 1$.

Experiment 3 replicated the results of Experiment 2 under conditions ensuring that participants perceived the appropriate number of objects.

Conclusions

Object-based effects of attention can be generated by local discontinuity (a gap) within a single object – an object effect with only one object.

The magnitude of the object effect (i.e., the decrement in target detection performance when the target appeared across the gap) was independent of the number of objects in the display.

These results are inconsistent with claims that object effects in this type of paradigm are caused by dividing or switching attention between two discrete object representations.

Instead, the results support the grouped-array theory of object-based attention, which holds that object perceptual structure (such as boundaries), constrains the spread of spatial attention.

References

Egly, R., Driver, J., & Rafal, R. D. (1994). Shifting visual attention between objects and locations: Evidence from normal and parietal lesion subjects. *Journal of Experimental Psychology: General, 123,* 161-177.

Lamy, D., & Egeth, H. (2002). Object-based selection: The role of attentional shifts. *Perception & Psychophysics, 64,* 52-66.

Vecera, S. P. (1994). Grouped Locations and Object-Based Attention: Comment on Egly, Driver and Rafal (1994). *Journal of Experimental Psychology: General, 123,* No. 3. 316-320.