

Attentional modulation of the fixation-offset effect

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INTRODUCTION

Saccades are initiated more quickly in the absence of an object at fixation. This **fixation-offset effect (FOE)** has been replicated widely (Abrams & Dobkin, 1994; Kingstone & Klein, 1993b; Reuter-Lorenz, Oonk, Barnes, & Hughes, 1995). However, few researchers have directly tested whether higher-level processes influence the FOE—and none have found support for that possibility. Additionally, prior investigations have used visual stimuli defined solely by luminance-defined contours. Such stimuli confound the presence of important perceptual objects with changes in activity in lower visual systems. Hence, it has not been possible to dissociate the lower-level from the higher-level explanations of the FOE. The present experiments manipulated the presence of important perceptual objects in order to learn more about the mechanisms underlying saccades.

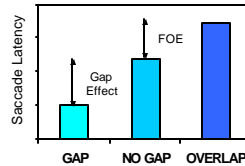
GENERAL METHODS

Task: Subjects were asked to fixate the object at the center of the display and make a quick eye movement to a target that appeared abruptly to the right or left of fixation, minimizing the response latency.

Eye Movement Conditions: Three intervals between fixation offset and target onset were examined: **Gap** (200 ms delay), **No gap** (simultaneous fixation offset and target onset), and **Overlap** (no offset of fixation).

Data Analysis: Average median saccade latencies were subjected to repeated measures analyses of variance (ANOVA). Pairwise comparisons were used to test significant main effects. Saccade amplitudes and errors were subjected to separate ANOVAs.

Hypothetical pattern of results generated in the experiments. The latency difference between the gap and no-gap conditions is referred to as the **gap effect**. The latency difference between the overlap and no-gap condition is the **Fixation Offset Effect (FOE)**. The FOE reflects the disengagement from fixation, presumably due to fixation cells in the superior colliculus (SC) that inhibit saccades during active fixation.



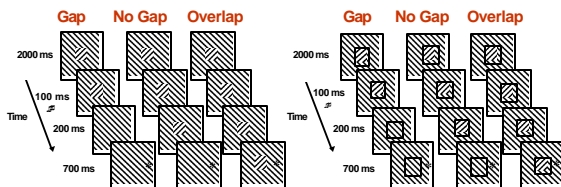
Experiment 1

Purpose: To determine whether the offset of a texture-defined object would generate a significant FOE.

Stimuli: Subjects fixated a perceptual object (20 pixels x 20 pixels) defined by a texture difference created against an equiluminant background.

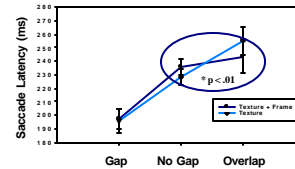
Texture-Only Trials

Texture + Frame Trials



Sequence of events for texture-only and texture + frame trials in Experiment 1. On frame trials the frame defined an object, hence the texture change did NOT result in the offset of an object.

Experiment 1 (continued)



Average median saccadic latencies for texture and texture + frame trials in Experiment 1. Vertical lines depict standard errors of the mean.

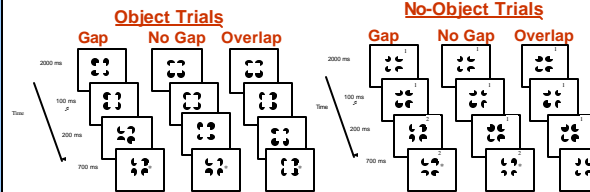
Conclusions

1. A texture-defined object engaged the system that inhibits saccades in much the same way as a true object.
2. The robust FOE on no-frame trials in the absence of one on frame trials is consistent with the hypothesis that the offset of the object was driving the reduction in saccadic latencies.

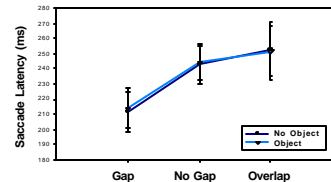
Experiment 2

Purpose: To determine whether the offset of a Kanizsa subjective figure would generate a significant FOE.

Stimuli: Subjects fixated the area between four closely-spaced inducers that were either aligned, thus forming an object, or misaligned, and not forming an object.



Sequence of events for trials in Experiment 2. On object trials, the perceptual object was removed by the rotation of the inducers in the gap and no-gap conditions. On no-object trials, the inducers were always misaligned but changes in the inducers occurred at the same times as for the object trials. (Numbers in each frame identify the different stimulus configurations but were not visible on the display.)



Average median saccadic latencies for object and no-object trials in experiment 2. Vertical lines depict standard errors of the mean.

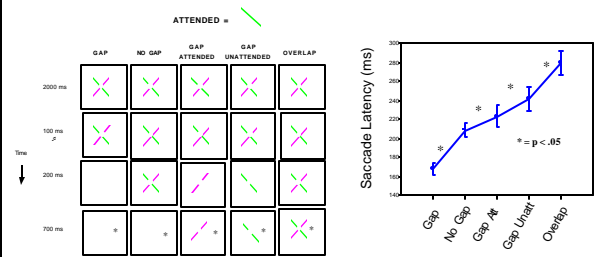
Conclusions

1. The offset of a Kanizsa figure did not facilitate latencies more than a nonspecific visual event at fixation.
2. An object defined by subjective contours did not engage the system that inhibited the production of saccades during fixation.

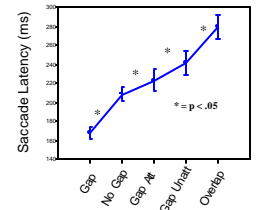
Experiment 3

Purpose: To determine whether the offset of an attended object yields a larger FOE than that of an unattended one when both objects are presented in the same spatial location.

Stimuli: Subjects fixated upon a square (3 pixels x 3 pixels) located at the intersection of two line segments. The line segments were contained within a square area 0.9° per side. Subjects were told to direct attention to one of the two line segments and to maintain that attentional set throughout the session. (Compliance was confirmed by the use of probe trials, not shown, in which a change occurred in either the attended or unattended line.)



Sequence of events on a trial in Experiment 3.



Average median saccadic latencies for all five conditions of gap. Vertical lines depict the standard error of the mean across subjects. (Gap-Att: attended object is removed from the display 200 ms before the target appears; Gap-Unatt: unattended object is removed from the display 200 ms before the target appears.)

Conclusions

1. The offset of an attended object yielded faster latencies than the offset of an unattended object. As a result the FOE was greater for attended objects.
2. Attention modulated the extent to which a fixated object could inhibit the initiation of saccades.

SUMMARY

The present results challenge the notion that the fixation-offset effect arises solely from low-level processes. The offset of an object at fixation that was defined by a texture difference equimulant with the background generated a robust FOE. However, the same pattern was not observed when the fixated object was a Kanizsa-type (subjective) figure. Furthermore, when subjects fixated both an attended and an unattended object attention modulated the size of the FOE. These findings show that the mechanisms that inhibit saccades during active fixation are affected by processes such as texture segregation and selective attention.

REFERENCES

- Abrams, R. A., & Dobkin, R. S. (1994). The gap effect and inhibition of return: interactive effects on eye movement latencies. *Experimental Brain Research*, 98, 483-487.
- Kingstone, A., & Klein, R. (1993b). Visual offsets facilitate saccadic latency. Does preengagement of visual-spatial attention mediate this gap effect? *Journal of Experimental Psychology: Human Perception and Performance*, 19, 1251-1265.
- Reuter-Lorenz, P. A., Oonk, H. M., Barnes, L. L., & Hughes, H. C. (1995). Effects of warning signals and fixation point offsets on the latencies of pro- vs. anti-saccades: Implications for an interpretation of the gap effect. *Experimental Brain Research*, 103, 287-293.