Spatial Biases in Scanning and Remembering Scenes

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Introduction

- Recently, Intraub, Hoffman, Wetherhold, and Stoehs (2006) discovered a left–right asymmetry in *boundary extension* (BE; false memory for scene layout).
- The scenes they used were unusual: there was always a salient object on the right and on the left. Also, the bias occurred only when observers were required to maintain fixation when the picture was briefly presented.
- When observers adjusted scene boundaries 2 s following stimulus offset, they included more unseen area on the right side than on the left.

- First time such an asymmetry had been reported for scene representation
- Scenes are idiosyncratic; most tests don't allow assessment of memory for individual view-boundary locations

Why A Leftward Bias In BE?

- Might a leftward bias in the distribution of attention *during the first fixation on a scene* underlie the observed rightward bias in BE?
- If more attention was allocated to the left sides of scenes, this could result in a larger BE error for the right sides.
- Indeed, withdrawal of attention from pictures under dual-task conditions resulted in more BE than for single task (Intraub, Daniels, Horowitz, & Wolfe, in press).

Hypotheses

If the distribution of attention were biased to the left side of space, then

1. Less BE should occur for the left sides of scenes than for the right (Exp. 1)
2. Observers should show a bias to direct their first saccade to the left (Exps. 2a and b)
3. Observers should show better memory for objects that appeared on the left sides than for those that appeared on the right (Exp. 3)

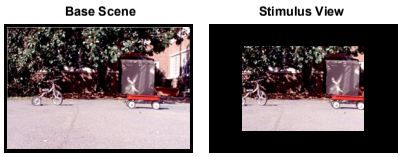
Experiment 1

Purpose: To determine whether the rightward bias in BE would replicate with a larger stimulus set than used by Intraub, Hoffman, et al. (2006) .

Rationale: To encourage encoding of overall scene views, observers were told to study each scene for a memory test, and that objects, background, and layout were all equally important. To discourage observers from relying on stimulus view size for making border adjustments, initial test views had their borders pulled either inward or outward, and observers had to move them to recreate the original view.

Observers: *N* = 24

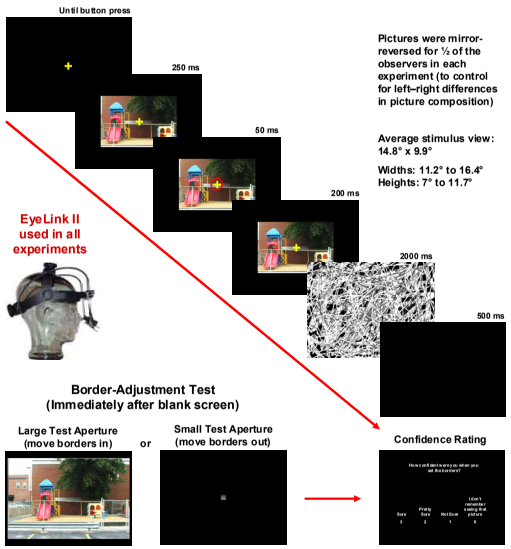
Stimuli: 30 pictures total (+ 11 practice). All pictures were digitized color photographs of indoor and outdoor scenes; each had a salient object on the left and right sides, as in Intraub, Hoffman, et al.



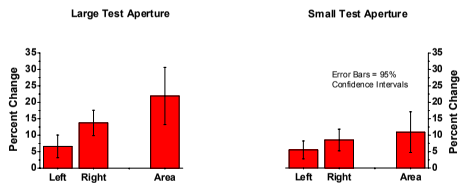
Task: Adjust each test picture's view to recreate the stimulus view by repositioning the picture's top, bottom, left, and right borders with the computer's mouse.

Design: 30 trials total (+ 21 practice). Initial test view was smaller than stimulus view on 50% of trials (*small-test-aperture* trials); larger on remaining 50% (*large-test-aperture* trials).

Experiment 1 Trial Sequence



Less Boundary Extension for the Left Sides of Scenes



- BE was found for overall views – observers revealed more of scenes than was actually shown
- More BE for right sides of scenes than for left, also replicating Intraub, Hoffman, et al. (2006)
- Large-test-aperture trials: right vs. left – 13.8% vs. 6.6%; $t(23) = 4.1$, $p < .05$
  Small-test-aperture trials: right vs. left – 8.5% vs. 5.5%; $t(23) = 2.3$, $p < .05$
- Only trials on which fixation was maintained were analyzed

Experiments 2a and b

Purpose: To determine whether observers were biased to initially look leftward when viewing scenes.

Rationale: To match viewing conditions in Exp. 1, scenes were shown for 500 ms in Exp. 2a. To better simulate normal free viewing, they were shown for 10 s in Exp. 2b.

Observers: Exp. 2a: *N* = 24; Exp 2b: *N* = 23

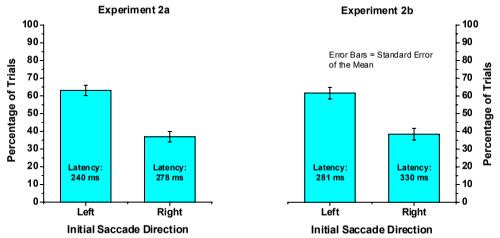
Stimuli: Same as in Exp. 1

Design and Procedure: Each trial was self-initiated with central fixation; each scene was followed by a 2000 ms mask and 500 ms blank as in Exp 1. Stimulus views, presentation order, and instructions for studying pictures were identical to Exp. 1.

Exp. 2a: 40 trials total (+ 4 practice). Stimuli were the 30 experimental scenes + the 10 practice scenes from Exp. 1

Exp. 2b: 30 trials total (+ 4 practice). Stimuli were the 30 experimental scenes from Exp. 1.

A Leftward Bias in Initial Saccade Direction



- Significant leftward bias in initial saccade direction for both Exps. 2a and b (for both normal and mirror-reversed pictures)
- Exp. 2a: left vs. right – 63% vs. 37%; $t(23) = 4.45$, $p < .05$
  Exp. 2b: left vs. right – 62% vs. 38%, $t(22) = 3.57$, $p < .05$
- This is consistent with a leftward bias in the distribution of attention during observers' initial fixations on the scenes, based on the linkage between overt attention shifts and saccades during free viewing (e.g., Deubel & Schneider, 1996; Hoffman & Subramaniam, 1995)
- [Trial-inclusion criteria: initial saccade latency > 150 ms (both 2a and b); at least 70% trials meeting latency criterion (Exp. 2b)]

Experiment 3

Purpose: To determine whether observers would have better memory for objects that appeared on the left sides of scenes than for those that appeared on the right sides when scenes were shown briefly and eye movements were prevented (as in Exp. 1).

Observers: *N* = 24

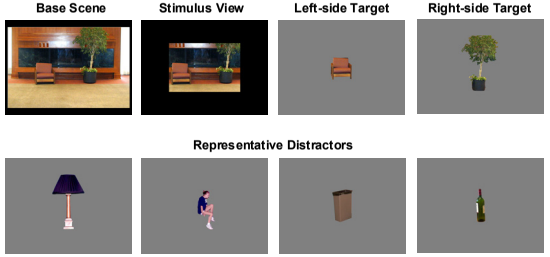
Stimuli: 40 pictures total (+ 4 practice); 10 new scenes served as buffer scenes for the stimulus sequence (5 were shown before the 30 experimental scenes; the other 5 were shown at the end of the sequence).

Procedure and Design: Observers self-initiated each trial with central fixation; each scene was shown for 500 ms, followed by a 2000 ms mask and 500 ms blank screen. The instructions for studying scenes were the same as in Exps. 1 and 2.

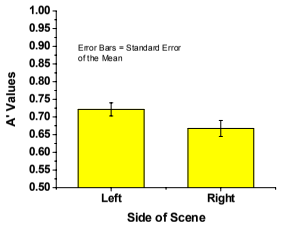
Recognition Test

- 60-item yes–no object-recognition test
- 40 target objects: left-side and right-side objects from 20 scenes
- 20 distractor objects taken from similar types of scenes
- All test items were cut out of their respective scenes and were shown on a blank gray background in the screen's center.
- Objects were shown without any surrounding background information that appeared in the stimulus view.
- Objects that were cropped in stimulus views of scenes were shown not cropped (or less cropped) at test.
- The same set of distractor items were used to compute false alarms for both left-side and right-side A' values.
- Observers rated confidence after each recognition response.
- Memory-test responses for targets were not included in analyses if fixation was not maintained on the scene in which they appeared.

Experiment 3 Stimulus and Test-Item Examples



Better Object-Recognition Memory for Left-Side Targets



- Significantly better recognition memory for left-side targets; left-side vs. right-side A' values: .72 vs. .67; $t(23) = 2.42$; $p < .05$

Summary and Conclusions

With a salient object on both the left and right, given just a single fixation, our results suggest that "all things being equal," there is a subtle leftward bias in the distribution of attention when we glimpse a scene.

In this series of experiments:

1. We replicated the asymmetrical BE error under these conditions (less BE on the left)
2. Demonstrated that in free viewing, the first saccade is biased to the left
3. Demonstrated better memory for objects on the left

We suggest that a leftward bias in the distribution of attention enhanced the representation of the left side of the view, thus attenuating the boundary error and enhancing object memory on the left. In addition, this bias tended to draw the eyes to the left. Why? The leftward bias may be related to hemispheric specialization or to reading direction (Fecteau & Enns, 2005; Pollatsek, Bolozky, Well, & Rayner, 1981). Alternately, it may be related to *pseudoneglect* (Bowers & Heilman, 1981; Jewell & McCourt, 2000), in which neurologically normal observers bias judgments of perceptual magnitude toward the left side of space (e.g., bisecting lines to the left of center). For example, in the greyscales task shown below, observers tend to judge the bottom rectangle as being darker than the top one (Mattingley, J. L. Bradshaw, Nettleton, & J. A. Bradshaw, 1994).

We want to stress that the leftward bias is a subtle one. Its influence is likely overridden by the idiosyncratic placement of objects in natural scenes (i.e., in most cases they are not "balanced" as in the current stimulus set). However, when object placement was balanced, this unexpected, yet highly consistent pattern of asymmetry emerged in spatial memory, object memory, and visual exploration of the scenes.

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Acknowledgments

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