Boundary Extension in the Transsaccadic Representation of Layout

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Introduction

- Typically, viewers remember seeing beyond the boundaries of the current view (*Boundary Extension* [BE]; Intraub & Richardson, 1989)
- BE is specific to memory for scenes, as opposed to other types of displays (Intraub et al., 1998), and neuroimaging evidence for BE has been observed specifically in scene-selective regions of the brain (PPA, RSC; Park et al., 2007)
- BE might facilitate integration of successive views, but … to do so it would have to be available during the next fixation
- Accordingly, it would need to occur following a retention interval as brief as a saccade's duration, and it would need to survive a saccade
- Here we examine the questions of 1) how rapidly following stimulus offset BE is available and 2) whether it is included in *transsaccadic memory* when tested immediately after a saccade

Experiment 1

Purpose: To determine how rapidly after stimulus offset BE would be found, and to determine whether BE would survive *conceptual masking* (Intraub, 1984; Potter, 1976). We replicated the Intraub et al. (1996) experiment with new pictures and tested briefer masked intervals (250 ms, 100 ms, 42 ms) to determine if there is a point at which participants correctly recognize the same view (i.e., no BE).

Rationale: We used a fully counterbalanced set of stimulus–test pairs to see if typical effects would occur at each masked interval. Stimuli and test items always appeared center screen to separate spatial effects from temporal effects. The 42 ms masked interval was selected to test a masked interval comparable to a "typical" saccade's duration.

Participants: N = 108 (36/masked interval)

Stimuli: 38 pictures total (+ 76 non-targets for RSVP sequences). Each tested picture had 2 versions: a close-up and a wide-angle version.

Close-Up Views | **Wide-Angle Views**

Task: Rate whether test picture was the same view, more close-up, or more wide-angle than initial stimulus on a 5-point scale (and rate confidence)

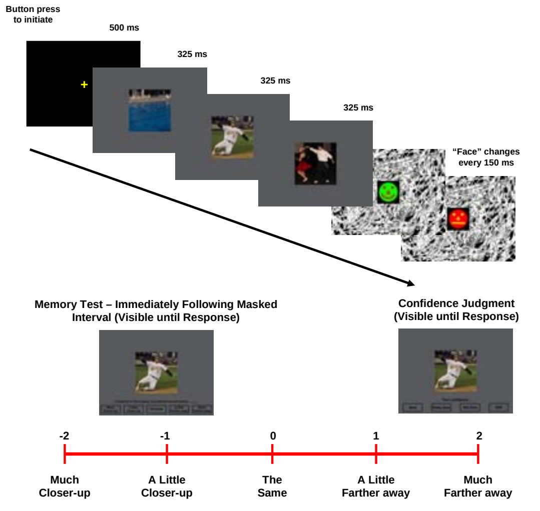
Design: 36 trials total (+ 2 practice); pictures were tested by the same view on 50% of trials. Stimulus view could be either close-up or wide-angle; test picture could also be either close-up or wide-angle, yielding 4 test types. Serial position and test type were fully crossed; every picture was tested in every condition across participants.

Test Types:

Same view:
- CC (close-up tested by a close-up)
- WW (wide-angle tested by a wide-angle)

Different view:
- CW (close-up tested by a wide-angle)
- WC (wide-angle tested by a close-up)

Sample Trial Sequence: Target Trial (CC: Close-up tested with Close-up)



Expected Test-Type Effects in BE

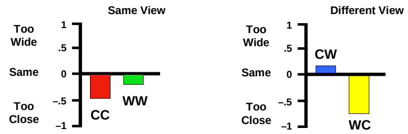
Test is the same view as stimulus:

- CC vs. WW: More BE for CCs
  - Why? A close-up view contains less information that would be expected to appear beyond the current view than a wide-angle view
  - More extrapolation = more BE

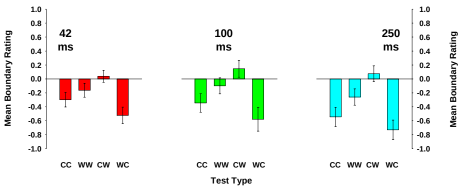
Test is a different view than stimulus:

- CW: Test item is rated "about the same view"
  - Why? The close-up view yields BE – the memory representation includes information that will be in the wide-angle version of the picture
  - Perceived disparity < actual physical disparity
- WC: Test item is rated "much too close"
  - Why? The wide-angle view generates some BE (less than close-up) – memory includes additional information not in the close-up
  - Perceived disparity > actual physical disparity

An Example of Typical BE Test-Type Effects

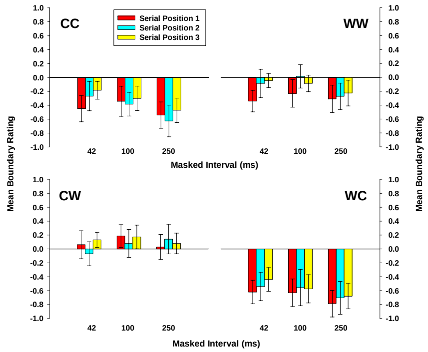


Test-Type Effects Appeared at Each Masked Interval



- Expected test-type effects appeared at each masked interval
- This pattern is mirrored across each masked interval

Recency Effects, But No Temporal Limits of BE



- BE found at <u>every</u> serial position for CCs – even after a 42-ms gap between stimulus and test
- Conceptual masking did not eliminate BE for items in serial positions 1 and 2
- CC: Less BE at serial position 3 than at serial position 1 at 42-ms masked interval
- CC: BE increased from 42-ms to 250-ms masked interval at serial position 3
- More BE for CCs than for WWs at each masked interval
- Significant CW–WC asymmetry at each masked interval
- No evidence for temporal <u>limits</u> of BE

Results

- BE was found at <u>all</u> masked intervals—as rapidly as 42 ms after stimulus offset
- Amount of BE appeared to increase with masked interval
- Expected patterns of test-type effects appeared at each masked interval
- Temporal limits of BE were not found

Experiment 2

Purpose: To determine whether BE would survive a saccade when memory for the view was tested immediately after the saccade.

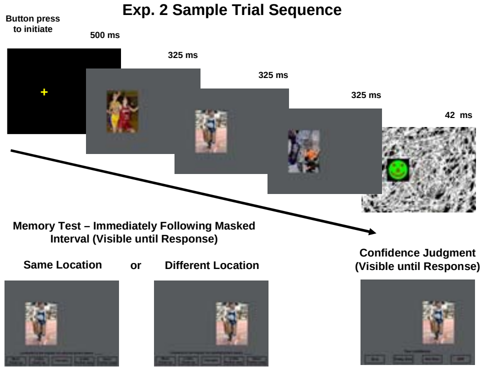
Rationale: Close-ups were always tested with identical close-ups to provide the most conservative test for BE. Stimuli appeared on one side of the screen; test items appeared either on the same side or the opposite side (necessitating a gaze shift). We tested the 42 ms interval from Experiment 1 to see if BE would be found when tested for immediately after a saccade. We recorded participants' eye movements (EyeLink II) to determine saccade latency, picture retention intervals, and whether participants maintained fixation during stimulus presentation.

Participants: N = 36

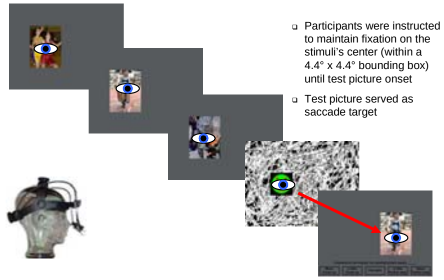
Stimuli: Same as in Experiment 1 (except for stimulus positioning).

Design: 36 trials total (+ 2 practice); test pictures were shown on the same side of the screen on 50% of trials *(maintain-fixation* trials) and on the opposite side of the screen on 50% of trials *(shift-gaze* trials). Mean center-to-center stimulus–test distance (shift-gaze trials) = 11.8° (range = 8.4° to 14.2°). Serial position and test location were fully crossed; every picture was tested in every condition across participants; and trial type was blocked. Rating scale used at test was the same as in Experiment 1.

Exp. 2 Sample Trial Sequence

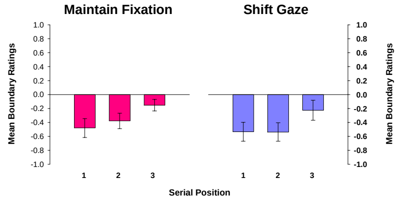


Experiment 2 Eyetracking: EyeLink II (SR Research)



- Participants were instructed to maintain fixation on the stimuli's center (within a 4.4° x 4.4° bounding box) until test picture onset
- Test picture served as saccade target

BE Was Neither Delayed Nor Attenuated By A Saccade



- Significant BE found at <u>every</u> serial position; less at serial position 3 than serial position 1
- Participants maintained fixation during stimulus presentation on 84% of maintain-fixation trials, 79% of shift-gaze trials
- Mean saccade latency (following test picture onset) = 264 ms
- Mean saccade duration = 64 ms
- Mean interval from final stimulus offset to first fixation on test picture = 370 ms (mask duration + mean saccade latency + mean saccade duration)

Conclusions

BE is a constructive error in memory for scenes. What is its early time course? Does it occur rapidly enough to be included in transsaccadic memory? In two experiments, we investigated these questions by testing memory for briefly presented scenes across masked intervals ranging from 250 ms to 42 ms. We found evidence for BE at even the briefest of these masked intervals. What's more, we found that BE was not eliminated by conceptual masking (Exp. 1 & 2), and that BE survived a saccade (Exp. 2). Finding that BE occurred across changes in gaze position and across a gap in sensory input as brief as a typical saccade suggests that BE would be <u>available</u> to facilitate the integration of successive views during active visual scanning.

What's more, BE's rapid time course suggests that it may begin during perception rather than in memory. Both amodal continuation and higher order expectation likely operate while a given view is visible. While visible, then, one's representation of the view would include both what is seen and what is understood to exist beyond its boundaries. During perception, the two can be differentiated. Once the sensory input is removed, however, the distinction between what was seen and what was perceived amodally becomes less clear—evidently quite rapidly. This can result in the error of commission known as BE, even under conditions where we might expect memory to be quite good.

References

Intraub, H. (1984). Conceptual masking: The effects of subsequent visual events on memory for pictures. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10*(1), 115–125.

Intraub, H., Gottesman, C. V., & Bills, A. J. (1998). Effects of perceiving and imagining scenes on memory for pictures. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*(1), 186–201.

Intraub, H., Gottesman, C. V., Willey, E. V., & Zuk, I. J. (1996). Boundary extension for briefly glimpsed photographs: Do common perceptual processes result in unexpected memory distortions? *Journal of Memory and Language, 35*, 118–134.

Intraub, H., & Richardson, M. (1989). Wide-angle memories of close-up scenes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*(2), 179–187.

Park, S., Intraub, H., Yi, D-J, Widders, D., & Chun, M. M. (2007). Beyond the edges of a view: Boundary extension in human scene-selective visual cortex. *Neuron, 54*, 335–342.

Potter, M. C. (1976). Short-term conceptual memory for pictures. *Journal of Experimental Psychology: Human Learning and Memory. 2*(5), 509–522.

Acknowledgments

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