Scene Context and Change Blindness: Memory Mediates Change Detection

Carrick C. Williams (carrick@eyelab.msu.edu)
Andrew Hollingworth (andrew@eyelab.msu.edu)
John M. Henderson (john@eyelab.msu.edu)
Department of Psychology and Cognitive Science Program
Michigan State University, East Lansing, MI 48824

Viewers often fail to detect changes to natural scenes when the change occurs during a visual disruption such as a saccadic eye movement. This *change blindness* phenomenon has led some researchers to claim that visual representation is limited to the currently attended object (e.g., Rensink, O'Regan & Clark, 1997). This *attention hypothesis* holds that once visual attention is withdrawn from an object, no visual object representation remains to support change detection. An alternative view, the *memory hypothesis*, holds that despite the change blindness phenomenon, a relatively detailed representation is retained in memory from previously attended objects (Hollingworth & Henderson, 1999).

To test these competing hypotheses, we examined participants' ability to detect changes to the visual form of a target object. Changes were made during a saccade that took the eyes away from the target object after it had been fixated the first time (Henderson & Hollingworth, 1999). Because attention precedes the eyes to the next fixation position, the target object was not within the current focus of attention when it changed. Thus, the attention hypothesis predicts that these changes should not be detected, whereas the memory hypothesis holds that visual memory can be detailed enough to support token-change detection.

In addition, we manipulated the semantic relationship between the target object and the scene in which it appeared. Research on long-term scene memory has demonstrated that semantically inconsistent (i.e., improbable) objects are retained more accurately in memory than consistent objects (Friedman, 1979). Thus, the memory hypothesis predicts not only above-floor change detection rates, but also a detection advantage for semantically inconsistent objects.

Method

Twelve volunteers' eye movements were monitored as they viewed 24 black-on-white line drawings of realistic scenes. In each scene a semantically consistent target object (e.g., mixer in kitchen) was chosen, and targets were swapped across scenes to create stimuli for the semantically inconsistent condition (e.g., mixer in farmyard). When a change occurred, the target was replaced with a different example of that type of object (e.g., the mixer replaced by a visually different mixer). A control condition was included in which no change occurred. Participants were instructed to view each scene to prepare for a memory test and to press a button if a change occurred.

Results

We examined the percentage of trials on which the participant detected a change in a scene. There was a reliable difference between the consistent (18.1%) and inconsistent conditions (35.2%), $F(1,11) = 5.28$, $p < .05$. This difference was likely due, at least in part, to the fact that gaze duration prior to the change was longer for inconsistent (628 ms) versus consistent targets (489 ms), $F(1,11) = 7.46$, $p < .02$. In addition, a significant percentage of detections (41%) was delayed more than 1500 ms after the change. Of these late detections, 94% occurred upon refixation of the target. Finally, for trials on which a change was not detected, mean gaze duration when the eyes returned to the changed object (749 ms) was longer compared to the equivalent entry in the control condition (499 ms), $F(1,11) = 6.29$, $p < .05$.

These data demonstrate that participants can detect changes to the visual form of an object that is not within the current focus of attention at the time of change. Thus, these data are consistent with the memory hypothesis but not with the attention hypothesis. The modulation of detection performance by semantic consistency provides converging evidence that inconsistent objects are preferentially retained in memory. In addition, the fact that many detections were delayed more than 1500 ms and that these detections tended to occur upon refixation suggests that visual information was often retained for a relatively long period of time and consulted only when focal attention was directed back to the changed region (Henderson & Hollingworth, 1999). Finally, the large implicit effect of change on gaze duration indicates that the explicit detection measure underestimated the extent to which visual information was retained in memory.

Acknowledgments

This research was support by NSF grants SBR 9617274 and ECS 9873531 to John M. Henderson and by an NSF Graduate Research Fellowship to Andrew Hollingworth.

References

Henderson, J. M., & Hollingworth, A. (1999). The role of fixation position in detecting scene changes across saccades. *Psychological Science, 10*, 438-443.

Hollingworth, A., & Henderson, J. M. (1999). Transsaccadic change blindness and long-term scene memory. Paper presented at Annual Workshop on Object Perception and Memory, Los Angeles.

Friedman, A. (1979). Framing pictures: The role of knowledge in automatized encoding and memory for gist. *Journal of Experimental Psychology: General, 108*, 316-355.

Rensink, R.A., O'Regan, J.K., & Clark, J.J. (1997). To see or not to see: The need for attention to perceive changes in scenes. *Psychological Science, 8*, 368-373.