Neither Change Blindness Nor Amnesia: Accurate Memory for Previously Attended Objects in Natural Scenes

Andrew Hollingworth & John M. Henderson, *Department of Psychology & Cognitive Science Program, Michigan State University*

1 INTRODUCTION

- What is the nature of the visual representation formed as humans view a natural scene for an extended period of time? Numerous studies, including change blindness demonstrations, have shown that the visual system does not construct a composite sensory image.
- Change blindness effects have been interpreted further as indicating that visual scene representation is both local and transient, limited almost exclusively to the currently attended object (Rensink, 2000). In this view, when attention is withdrawn from an object, any coherent visual representation of that object disintegrates, leaving no memory trace (Wolfe, 1999), a *visual transience hypothesis*.
- This visual transience hypothesis appears at odds with a large literature demonstrating excellent long-term memory for visual scenes (e.g., Standing et al., 1970).
- In this study, we investigated the visual representation of previously attended objects in natural scenes. When attention is withdrawn from an object, does the visual representation of that object decay immediately (as proposed by the *visual transience hypothesis*), or are visual representations retained and accumulated in memory (consistent with the picture memory literature)?

2 OVERVIEW OF EXPERIMENTS

Experiment 1

Participants viewed 36 3D-rendered scenes for 20s each as their eye movements were monitored. They were instructed to prepare for a difficult memory test and in addition to monitor for object changes.

A. Saccade-contingent change paradigm. The visual form of a target object was changed during a saccade to a different scene region after the target had been fixated at least once.

B. Long-term memory test. For scenes in which no change occurred, long-term memory was tested by later having participants discriminate studied scenes from distractor scenes that differed only in the visual form of the target object.

Experiment 2: Online memory test

The target object was masked during a saccade to a different region of the scene after the target had been fixated at least once. Two object alternatives were then displayed in the scene: the target and a visually different distractor.

Because attention had been withdrawn from the target object prior to the change or initiation of the forced choice test, the visual transience hypothesis predicts that 1) change detection should be at floor and 2) forced-choice discrimination should be at chance.

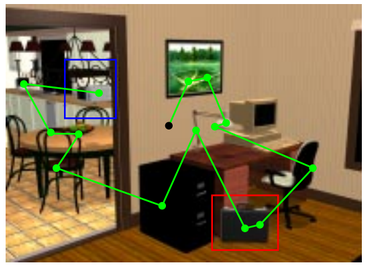
3 EXPERIMENT 1

A. Saccade-Contingent Change Paradigm

Target Object Region fixated at least once prior to change.

Target object changed during saccade as eyes cross boundary to a Different Object Region.

(Green lines represent saccades, dots fixations. Initial fixation is displayed in black.)



The target object was 1) attended prior to the change but 2) not currently attended when the change occurred, as attention was directed to the saccade target in the different object region.

Detail of target object for each change condition

Explicit Change Detection

Change Condition	Percent Detection
Token Substitution	**26.0**
Rotation	**29.2**
No Change Control (false alarm rate)	**4.2**

- Change detection was significantly higher than false alarm rate.
- 89% of changes were detected when the target happened to be refixated later in viewing, suggesting long-term retention and subsequent retrieval, cued by refixation.

Implicit Change Detection. Gaze duration for first entry into target object region after change: *miss* trials in change conditions compared to no change control.

Change Condition	Gaze Duration (ms)
Token Substitution Miss[1]	**652***
Rotation Miss	**586**
No Change Control[1]	**507**

* Reliably different from No Change Control.
[1] Means include data from companion experiment.

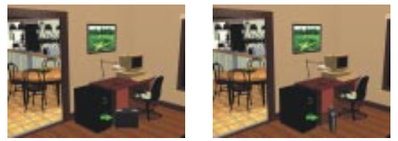
For miss trials in token substitution condition, gaze duration on changed object reliably higher than for no change control, suggesting explicit detection significantly underestimated visual representation. This effect has been replicated twice in subsequent experiments.

4 EXPERIMENT 1, cont.

B. Long-Term Memory Test

For no change control scenes, two scene alternatives displayed after study session that differed only in target object (different token or different orientation). Target was marked by arrow.

Sample stimuli in orientation discrimination condition



Condition	Percent Correct
Token Discrimination	**80.6**
Orientation Discrimination	**81.9**

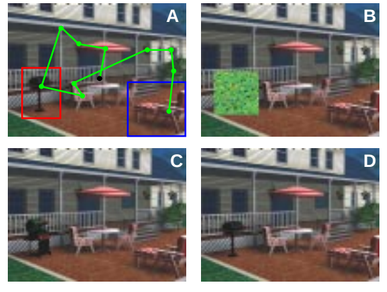
Accurate LTM for the visual form of target object consistent with picture memory literature but not with visual transience hypothesis.

5 EXPERIMENT 2

Online Memory Test

Target Object Region fixated at least once. As eyes cross boundary to a Different Object Region, target occluded by mask.

Participant presses button to initiate forced-choice test. Target and distractor object (different token or different orientation) then presented.

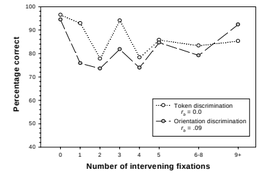


Condition	Percent Correct
Token Discrimination	**86.9**
Orientation Discrimination	**81.9**

Accurate memory for the visual form of previously attended objects found during online perceptual processing of a scene.

6 EXPERIMENT 2, cont.

To examine visual representation after the withdrawal of attention more closely, discrimination performance was calculated as a function of the number of fixations that intervened between the onset of the mask and the last fixation on the target object. If visual representations decay quickly upon the withdrawal of attention, discrimination performance should decrease sharply. However, there was no evidence of reduced discrimination performance as the number of intervening fixations increased, indicating the retention of visual codes in a relatively stable form.



7 CONCLUSIONS

- Visual object representations are retained in memory from previously attended objects, forming a relatively detailed scene representation (though clearly less detailed than a composite sensory image) as the eyes and attention are directed to multiple local regions. Thus, our results are consistent with the picture memory literature but not with the visual transience hypothesis.
- Sustained attention to a changing object is not a necessary condition for detecting that change.
- Explicit change detection significantly underestimates the visual representation of a scene. When changes are missed, robust effects of that change on fixation duration are nonetheless observed.
- We propose that during dynamic scene viewing, abstracted visual representations from attended objects are quickly transferred to LTM and indexed to a spatial position within a scene map. When attention and the eyes are directed back to the relevant position, LTM representations are retrieved, supporting change detection and forced-choice discrimination.

REFERENCES

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Standing, L., Conezio, J., & Haber, R. N. (1970). Perception and memory for pictures: Single-trial learning of 2500 visual stimuli. *Psychonomic Science, 19*, 73-74.

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