An Eye-Tracking Study of Infants' Accumulation of Visual Memories in Scenes

Sylvia B. Guillory, M.Sc., Nicole Scipione, Zsuzsa Kaldy, Ph.D.
University of Massachusetts Boston, Boston, MA

Question: How are object representations built up in scenes over time (accumulation) and how stable are these representation when exposed to interference (persistence)?

Our Visual Working Memory (VWM) stores information about both objects and scenes. Object VWM has been studied extensively in infants, but VWM for objects situated in scenes has only been studied recently [1,2,3]. Scenes can facilitate how well we can remember particular objects in them [4]. In the current study, we are testing how visual information accumulates over time and may persist despite interruptions in infants. Longer exposures lead to more accurate memories in adults (accumulation). As well, when adults view a scene for four separate 1-second exposures, they remember it exactly as accurately as when they could view it for 4 continuous seconds (persistence) [5,6].

Our first goal was to establish whether information builds up over time in infants the same way as it does in adults. Our second objective was to investigate whether the visual memories that infants build up can persist over interruptions, just as in adults. We ran an adult study to replicate the main effects of accumulation and persistence demonstrated by Melcher and colleagues [5,6] with our stimuli and parameters. Then we tested 7-16-month-old infants in a minimally modified version of this paradigm.

Participants

24 adults (16 females; M: 25.1 +/-4.95 yrs; range 18-40). All had normal or corrected-to-normal vision with no history of colorblindess in the family.

30 full-term, healthy infants participated in the infant study. Of these, 26 infants (11 females) met inclusion criteria of completing at least 1 test trial (range: 7;17-16;4; M = 10;10).

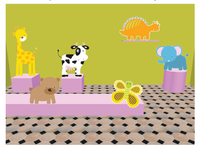
Methods

Responses for the adult study were collected using a keyboard. A Tobii T120 eye tracker was used to collect eye gaze data in the infant group.

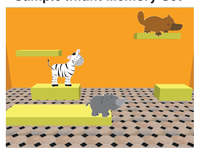
For the adult study, each display of the memory set comprised of six objects that were placed on the top surface of the furniture and were tested on a subset of three. The infant group was exposed to three objects in both the memory and the test set.

Stimuli

Sample Adult Memory Set



Sample Infant Memory Set

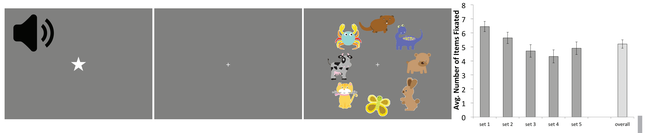


Conditions

Duration	Cont. (1 exposure)	2 exposures	4 exposures
1 sec	X	X	X
2 sec	X*	X*	
4 sec	X*		

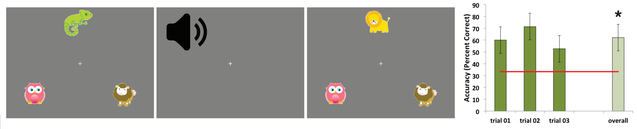
* both adult and infant conditions

Familiarization - stimuli



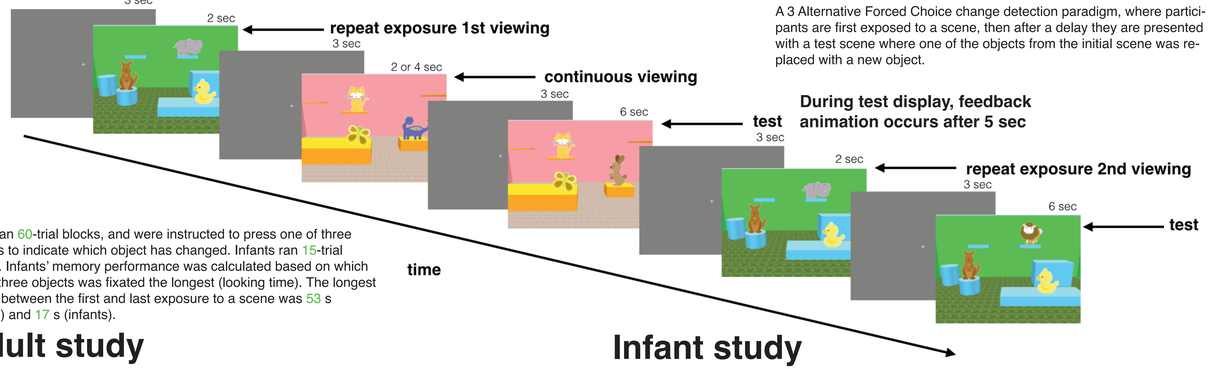
Eight objects were displayed at a time on a grey background for five seconds (adults) and 10 seconds (infants). Infants were able to fixate 5.21+/- 1.7 objects.

Familiarization - task



A change detection task twith a set of three objects were displayed for 1 s. After a 1 s delay, participants heard a sound effect (chime) and then a test display where one of the three objects have changed. Infants looked at the changed object significantly above chance (33%): t(25) = 4.68, p = < 0.001, (M = 62.18 +/- 31.5%).

Memory Task

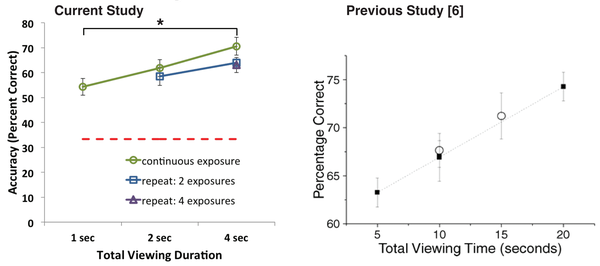


A 3 Alternative Forced Choice change detection paradigm, where participants are first exposed to a scene, then after a delay they are presented with a test scene where one of the objects from the initial scene was replaced with a new object.

During test display, feedback animation occurs after 5 sec

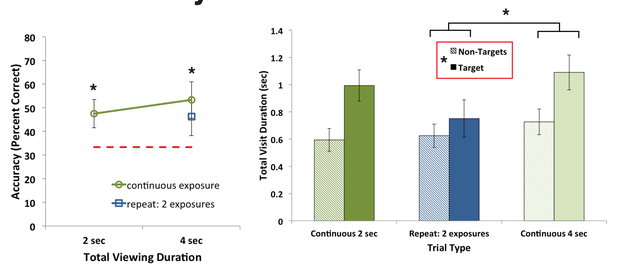
Adult ran 60-trial blocks, and were instructed to press one of three buttons to indicate which object has changed. Infants ran 15-trial blocks. Infants' memory performance was calculated based on which of the three objects was fixated the longest (looking time). The longest period between the first and last exposure to a scene was 53 s (adults) and 17 s (infants).

Adult study



Overall, participants performed significantly better than chance (M = 61.52% +/-10.56, p < 0.01). There was a significant difference in performance, where the 1 s exposure condition (M = 54.6% +/- 16.7) was less accurate compared to the 4 s exposure condition (M = 70.8 +/- 14.9). There were no significant differences in performance whether or not there were intervening scenes: 2 s continuous (M = 62.0% +/- 16.7) vs. 1x2 s exposures (M = 58.8% +/- 19.6) or 4 s continuous (M = 70.8%, SD = 17.4) vs. 2x2 s exposure (M = 64.1% +/- 17.7) vs. 4x1 s exposure (M = 63.3% +/- 14.9).

Infant study



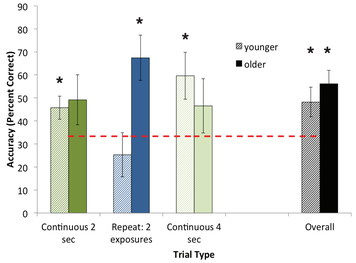
Accuracy was calculated based on looking time for the changed object was greater than both non-target objects. Overall, infants' performance was significantly better than chance (M = 50.24 +/- 22.60%, p = < 0.001). In the 4 s and 2 s continuous trials, infants performed better than chance (M = 53.33 +/- 38.49%, p = 0.016 and M= 47.54 +/-28.88%, p = .028). Infants were at chance in the 2x2 s exposures condition (M = 46.37 +/- 38.09%).

Infant Study Cont:

An analysis of total looking time by trial type (3) and by object type (2), revealed a significant main effect of trial type, F(2,50) = 6.43, p = 0.003. Looking time in the 2x2 s trials (M = 0.696, +/-0.096 s) was less than in the 4 s continuous trials (M = .916, +/-.099), There was also a main effect of object type, F(1,25) = 30.11, p < 0.001, where Targets (M = 0.97, +/-0.11 s) were looked at longer than Non-Targets (M = 0.65, +/- 0.50 s).

Overall, infants completed 64% of the 2 s cont. trials, 47% of the 2 exposures, and 65% of the 4 s cont. trials.

Effect of Age



Younger group:
Mean age: 8-mo 17 days
SD: 16.23-mo

Older group
Mean age: 12-mo 9 days
SD: 12.30-mo

We performed a median split by age in the infant group to investigate developmental changes in performance. We found that overall, both age groups performed better than chance (younger: M = 47.94+/- 21.63%, p < 0.031; older: M = 52.53+/- 24.19%, p < 0.014). While older infants' performance was better, this difference was not significant.

Summary

(1) We replicated earlier findings by Melcher and colleagues [5,6] in adults with our stimuli:
— longer exposures increase memory accuracy in adults (accumulation of information)
— adults are able to continuously maintain memory representations over interruptions and continue to accumulate additional information on subsequent exposures (persistence)

(2) Infants performed above chance in our change detection paradigm as demonstrated by two measures (both accuracy and absolute looking time).
— longer exposures increase memory accuracy in infants, too
— we could not find strong evidence for persistence of accumulation over interruptions.
Follow up studies will investigate whether longer exposure times may help infants to successfully accumulate visual information over interruptions.

Conclusion: Infants may require longer exposures to build-up a stable memory representation for objects in scenes.

References
[1] Duh, S., Wang, S. *Cogn Psychol* 72, 142-61 (2014).
[2] Richmond, J, Nelson, CA. *Dev Sci* 12, 549-56 (2009).
[3] Bornstein, MH, Mash, C., Arterberry, ME. *Dev Psychol* 47, 364-75 (2011).
[4] Hollingworth, A. *J Exp Psychol Hum Percept Perform* 33, 31-47(2007).
[5] Melcher, D. *Nature* 412, 401 (2001).
[6] Melcher, D. *J Vis* 6, 8-17(2006).