

*Studies in Perception and Action XIII*  
*H. Heft & K. L. Marsh (Eds.)*  
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## The Effects of Bimodal and Unimodal Familiarization on Infants' Memory for Unimodal Events

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We live in a world of objects and events that are multimodal and dynamic. Historically, however, much of the research in the area of sensory development has focused on the development of a single sense modality such as infants' ability to visually discriminate various faces/patterns or their ability to auditorally recognize a particular voice, despite the fact that these abilities develop in a multimodal context. While researchers have begun to examine infants' capacity for intersensory perception, as well as generate hypotheses regarding the nature of its development and its relationship to learning in early development (Lewkowicz & Lickliter, 1994; Lickliter & Bahrick 2000), little research has examined the relationship between intersensory perception and early memory development in human infants. Much of the research that has examined the development of memory in human infants has also largely focused on infants' memory for modality specific properties such as form, pattern, orientation, and color (e.g., Cohen & Gelber, 1975; Slater, 1985). More recently, however, research has begun to examine infants' memory for dynamic events (Bahrick & Pickens, 1995; Bahrick, Hernandez-Reif, & Pickens, 1997; Courage & Howe, 1998) as well as infants' long-term event memory using the mobile conjugate reinforcement paradigm (Davis & Rovee-Collier, 1983; Hayne, Rovee-Collier, & Perris 1987; Rovee-Collier & Fagan, 1981). Still, little is known regarding the effects of intersensory perception and early memory development, and it is important to do so given the multimodal nature of infants' environment and the fact that infants use multisensory information in learning about and organizing their world in a largely veridical manner. Given that the presence or absence of multimodal stimulation affects infants' perceptual attention; it is also possible that the presence or absence of multimodal information affects what infants remember about a particular event. The purpose of the current study was to examine the effects of redundant (audio-visual) and non-redundant (visual) familiarization on infants' memory for the unimodal property of visual orientation.

### **Method**

Forty-eight three-month-olds, seventy-two five- and seventy-two nine-month-olds were familiarized (120s) to films of a brightly colored plastic

hammer moving up and down striking a light colored wooden surface in a distinctive pattern. Infants were randomly assigned to one of two familiarization conditions (bimodal auditory-visual or unimodal visual) and one of three retention intervals (5-minutes, 2-weeks, or 1-month). Following the familiarization phase, infants received two 60s test trials. The visual preference memory test for orientation consisted of two silent, side-by-side, 60s trials of the hammer moving at familiar orientation, and the adjacent monitor presented the same hammer moving at the novel orientation (i.e., rotated 180°).

## Results

Following either unimodal or bimodal familiarization at the 5-minute as well as the 2-week retention intervals, three-month-olds did not demonstrate any preference for either the event used during familiarization or the novel event. No three-month-olds were tested at the one-month delay. At the 5-minute retention interval five month-olds, however, preferred the novel orientation following unimodal familiarization (Figure 1),  $M = 61\%$ ;  $t(11) = 2.87$ ,  $p = .02$ , but not bimodal familiarization (Figure 2),  $M = 53\%$ ;  $t(11) = 1.53$ ,  $p = .2$ . At the two-week retention interval 5-month-olds demonstrated no preference for either the familiar or unfamiliar event following bimodal or unimodal familiarization. Following the 1-month retention interval however, 5-month-olds in the unimodal familiarization condition showed a significant preference for the familiar event,  $M = 44\%$ ;  $t(11) = 3.03$ ,  $p = .011$ . Five-month-olds in the bimodal condition did not exhibit a visual preference for either the familiar or unfamiliar event following a 1-month delay. The 9-month-olds, however, showed a preference for the novel orientation given either bimodal,  $M = 59\%$ ;  $t(11) = 3.87$ ,  $p = .003$ , or unimodal stimulation,  $M = 63\%$ ;  $t(11) = 7.4$ ,  $p = .001$ , following a 5-minute delay. At the 2-week delay, 9-month-olds demonstrated a null preference for the novel orientation when provided bimodal or unimodal familiarization (all  $p$ 's  $> .1$ ). Finally following a 1-month delay, 9-month-olds in the bimodal,  $M = 42\%$ ;  $t(11) = 3.01$ ,  $p = .012$ , and unimodal,  $M = 38\%$ ;  $t(11) = 3.9$ ,  $p = .002$ , conditions demonstrated a familiarity preference.

## Discussion

Three-month-olds failed to show reliable memory for the orientation of an event when the event was presented silently (i.e., unimodally), or when the event could be seen and heard (i.e., bimodally). Five-month-olds, however, demonstrated a novelty preference at the 5-minute delay when the event was presented unimodally, but not bimodally. No preference for either the familiar or novel event was demonstrated at the 2-week retention interval. Finally, only those 5-month-olds in the unimodal condition showed memory for the event (in this case a familiarity preference) at the 1-month retention interval. These results are consistent with previous research assessing infants' memory for dynamic events. That is, others have demonstrated that infants' early memories are exhibited by a novelty preference, after an intermediate delay infants often show a null preference and following longer delay infants frequently exhibit a familiarity preference.

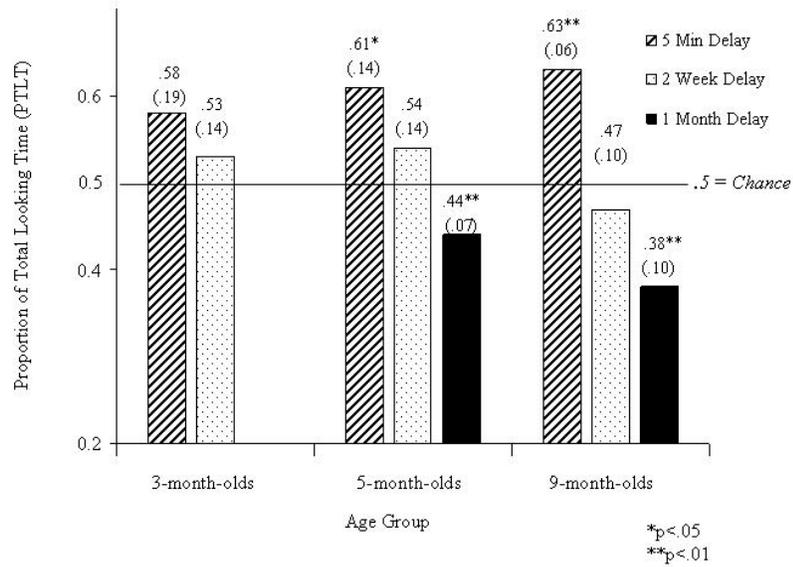


Figure 1. Unimodal familiarization: Proportions of total looking time and standard deviations to the novel visual orientation across retention intervals of 5-minute, 2-week, and 1-month delay as a function of age.

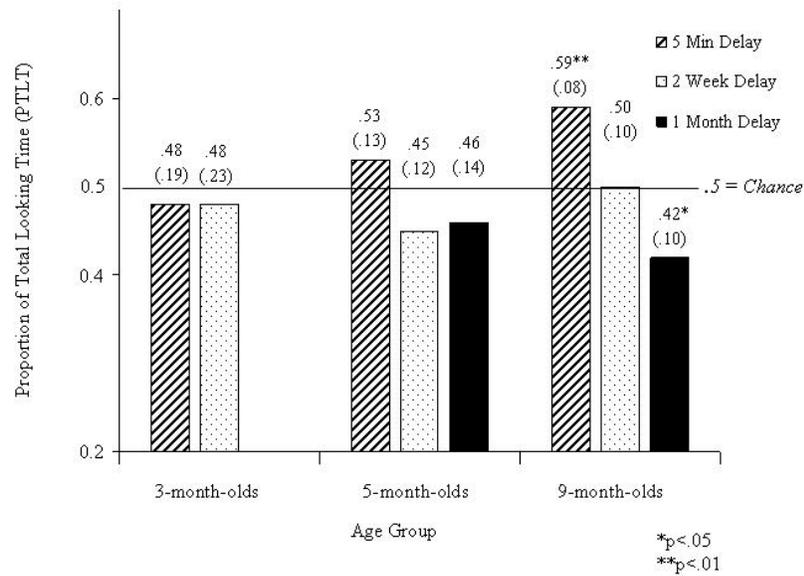


Figure 2. Bimodal familiarization: Proportions of total looking time and standard deviations to the novel visual orientation across retention intervals of 5-minute, 2-week, and 1-month delay as a function of age.

These results confirm and extend Bahrnick et al.'s (2004) intersensory redundancy hypothesis which states that in early development or when first perceiving an event, those properties specific to the visual modality (i.e., color, orientation) are most easily perceived when presented unimodally (i.e. silently) but not when presented bimodally (i.e. seen and heard). A second prediction, based on the intersensory redundancy hypothesis, is that with development/experience older infants, however, should be able to perceive and subsequently remember a unimodal property when presented under either unimodal or bimodal conditions. The results of the 9-month-olds confirm this prediction. Nine-month-olds in both the unimodal and bimodal conditions showed memory (i.e., a novelty preference) following the 5-minute delay. Nine-month-olds in the bimodal and unimodal conditions exhibited a familiarity preference following a 1-month delay. Together these results replicate the shifting pattern of infant memory (novel, null and familiarity) for dynamic events as a function of short, intermediate, and longer retention intervals, respectively, and these results demonstrate that predictions based on the intersensory redundancy hypothesis extend to infants' memory for dynamic events.

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