

PAPER

Object individuation in young infants: Further evidence with an event-monitoring paradigm

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Abstract

Recent results indicate that, when tested with an event-monitoring task, 7.5- and 9.5-month-olds give evidence that they can individuate objects in different-objects occlusion events – events in which two distinct objects appear successively on either side of an occluder (Wilcox and Baillargeon, in press). The present research sought to confirm and extend these findings. The experiments examined 7.5- and 4.5-month-olds' ability to correctly interpret a different-objects (ball-box condition) and a same-object (ball-ball condition) occlusion event. The infants in the ball-box condition saw a test event in which a ball disappeared behind the left edge of a screen; after a pause, a box emerged from behind the screen's right edge. For half of the infants (wide-screen event), the screen was wide and could occlude the ball and box simultaneously; for the other infants (narrow-screen event), the screen was narrow and should not have been able to occlude the ball and box at the same time. The infants in the ball-ball condition saw identical wide- and narrow-screen events except that the ball appeared on both sides of the screen. The infants in the ball-box condition looked reliably longer at the narrow- than at the wide-screen event, whereas those in the ball-ball condition tended to look equally at the events. These results suggest that the ball-box infants (a) were led by the featural differences between the ball and box to view them as distinct objects; (b) judged that the ball and box could both be occluded by the wide but not the narrow screen; and (c) were surprised in the narrow-screen event when this judgment was violated. In contrast, the ball-ball infants (a) assumed, based on the featural similarities of the balls that appeared on either side of the screen, that they were one and the same ball, and (b) realized that the ball could be occluded by either the wide or the narrow screen. These results indicate that, by 4.5 months of age, infants are able to use featural information to correctly interpret different-objects and same-object occlusion events. These findings are discussed in the context of the newly-drawn distinction between event-monitoring and event-mapping paradigms (Wilcox and Baillargeon, in press).

As they look about them, infants often observe occlusion events: a parent may leave a room or kneel behind a counter, a sibling may slide under a blanket or crouch behind a sofa, a toy car may roll into a box or under a bed. How well do infants understand such events? Traditionally, investigators assumed that infants possess very little knowledge about occlusion events (e.g., Piaget, 1954). This conclusion was based primarily on results obtained with object-manipulation measures. With the advent of more sensitive, visual-attention measures, however, researchers have come to realize that even young infants are able to represent and to reason¹ about occlusion events (for reviews, see Bailargeon, 1993; Mandler, in press; and Spelke, Breinlinger, Macomber, and Jacobson, 1992).

Many of the investigations of infants' responses to occlusion events that have been conducted using visual-attention measures have shared the same general approach. In a typical experiment, infants first see one or more objects in an otherwise empty apparatus; infants are thus given unambiguous spatiotemporal information

¹The term 'reason' is used here very generally to refer to the mental processes involved in the representation and manipulation (e.g., selection, retrieval, comparison) of information (e.g., perceptual representations, images, concepts). One reason for preferring the term 'reason' to other terms is that it conveys an element of directedness (Gleitman, 1991): it suggests that infants' mental activities are aimed at a particular goal (e.g., determining whether or not two objects can be simultaneously occluded when behind a narrow screen).

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about the number of objects present in the apparatus. Next, a screen is introduced and the objects are occluded. Test trials are designed to examine whether infants realize that the occluded objects (a) continue to exist; (b) retain their featural and spatial properties; and (c) remain subject to the physical regularities that govern the behavior of visible objects (e.g., Arterberry, 1993; Baillargeon, 1986, 1987; Baillargeon, Graber, DeVos, and Black, 1990; Baillargeon, Spelke, and Wasserman, 1985; Peterson, 1997; Spelke *et al.*, 1992; Wilcox, Nadel, and Rosser, 1996).

As an illustration of this approach, consider an experiment conducted by Spelke *et al.* (1992) with 4-month-olds. The infants were habituated to the following event sequence. First, a ball was held above a gap in a large horizontal surface positioned above an apparatus floor; the ball was slightly smaller than the gap. Next, a screen was raised to hide the gap, and the ball was dropped behind the screen. After a pause, the screen was removed to reveal the ball resting on the apparatus floor, below the gap. Following habituation, the infants saw a possible and an impossible test event. These events were identical to the habituation event except that a smaller (possible event) or a larger (impossible event) ball was used. The infants looked reliably longer at the impossible than at the possible event, suggesting that they (a) believed that each ball continued to exist and retained its width behind the screen; (b) realized that the width of each ball relative to that of the gap determined whether the ball could pass through the gap; and therefore (c) were surprised when the large but not the small ball was revealed below the gap.

In contrast to the experiments discussed above, recent investigations of infants' responses to occlusion events have tended to focus on a different set of issues. In a typical experiment, infants first see objects appear successively at the opposite edges of a screen; infants are thus *not* given unambiguous spatiotemporal information about the number of objects in the apparatus. Test trials are designed to examine whether infants are capable of using alternative sources of information, such as featural information, to determine how many objects are present behind the screen – or, in other words, to individuate the objects involved in the event (e.g., Leslie, Hall, and Tremoulet, 1996; Spelke, Kestenbaum, Simons, and Wein, 1995; Wilcox and Baillargeon, in press; Xu and Carey, 1996). The present experiments built on these results and examined 7.5- and 4.5-month-olds' ability to use featural information to individuate objects in occlusion events. Before describing this research, we first review recent findings in this area.

Event monitoring and event mapping

Are infants, like adults, able to use featural information to determine how many objects are involved in an occlusion event? Recent findings indicate that the answer to this question depends on the paradigm that is used to ask it: experiments conducted with *event-mapping* tasks have typically yielded negative results, whereas experiments conducted with *event-monitoring* tasks have typically produced positive results. In event-mapping tasks, infants first see an occlusion event in which one or two objects move back and forth behind a screen. Next, the screen is removed, and infants are shown a test display involving either one or two objects. In order to respond correctly to each test display, we have argued (Wilcox and Baillargeon, in press), infants must retrieve a representation of the occlusion event, map it onto the display before them, and judge whether the two are consistent. In event-monitoring tasks, infants again watch an occlusion event in which one or two objects move back and forth behind a screen. However, the screen is *not* removed; infants simply monitor the event as it unfolds, and judge whether successive portions of the event are consistent. Below, we illustrate the contrast between event-mapping and event-monitoring tasks with two examples. In the first, we consider experiments that presented infants with occlusion events in which the same object appeared on either side of the occluder (same-object events); in the second example, we focus on experiments in which different objects appeared on the two sides of the occluder (different-objects events).

Same-object occlusion events

Spelke *et al.* (1995) examined 4-month-olds' responses to a same-object occlusion event using an event-mapping task. The infants were first habituated to a cylinder that moved back and forth along a track whose center was occluded by a wide screen. Next, the screen was removed, and the infants saw a one- and a two-cylinder test event. In the one-cylinder event, a single cylinder moved back and forth along the track. In the two-cylinder event, two identical cylinders moved sequentially along the track, one to the left and one to the right of the area formerly occluded by the habituation screen. The infants tended to look equally at the one- and two-cylinder test events. This negative result was confirmed in a second experiment conducted with a similar procedure (Spelke *et al.*, 1995). The authors concluded that 4-month-olds make no assumption, when they see an object move back and forth behind a screen, as to whether one or two objects are involved in the event.

This conclusion is inconsistent with the results of experiments conducted with infants aged 2.5 to 5.5 months using event-monitoring tasks (e.g., Aguiar and Baillargeon, 1997a, b; Baillargeon and DeVos, 1991; Baillargeon and Graber, 1987). In one experiment, for example, 3-month-olds were habituated to a toy mouse that moved back and forth behind a wide screen (Aguiar and Baillargeon, 1997a). Following habituation, the infants saw a possible and an impossible test event. These events were similar to the habituation event except that a portion of the screen's midsection was removed to create a large window. In the possible event, the window was located in the screen's upper half; the mouse was shorter than the window's lower edge and so did not appear in the window when passing behind the screen. In the impossible event, the window was located in the screen's lower half; in this event, the mouse should have appeared in the window but did not in fact do so. The infants looked reliably longer at the impossible than at the possible event. These and control results indicated that the infants (a) believed that a single mouse was involved in the habituation and test events; (b) expected the mouse to appear in the low but not the high window; and hence (c) were surprised in the impossible event when this expectation was violated. Had the infants been unsure about the number of mice involved in the habituation and test events, they would have had no reason to be surprised when no mouse appeared in the low window in the impossible event; the fact that they did show surprise at this event indicates that they assumed that a single mouse was present in the apparatus (see Aguiar and Baillargeon, 1997a).

The discrepancy between the results of Spelke *et al.* (1995) and Aguiar and Baillargeon (1997a) is not entirely surprising when one considers the requirements associated with their respective tasks. To be successful, the infants tested by Spelke *et al.* had to compare the one- or two-cylinder test event before them to the habituation event they had seen earlier. The infants thus had to retrieve a representation of the habituation event, map it onto the test event before them, and determine whether the two were consistent. The situation was very different for the infants tested by Aguiar and Baillargeon. To correctly respond to the possible and impossible test events, the infants did not need to compare them to the earlier habituation event;² the infants had only to focus on the test event before them and judge whether successive portions of the event were

consistent (see also Aguiar and Baillargeon, 1997b; Baillargeon and DeVos, 1991; and Baillargeon and Graber, 1987).

Taken together, the findings presented above suggest two conclusions. First, infants as young as 2.5 or 3 months of age are able to individuate objects in same-object occlusion events. Second, whether infants give evidence of this ability depends on the task that is used to assess it: tasks that require infants to engage in event mapping are less likely to yield positive results than are tasks that require only event monitoring.

Different-objects occlusion events

Xu and Carey (1996) examined 10-month-olds' responses to different-objects occlusion events using an event-mapping task. The infants first received introductory trials in which they saw one or two objects (e.g., a rabbit; a rabbit and a basket). Next, the infants received test trials. At the start of each trial, one object (e.g., a ball) emerged from behind the left edge of a wide screen and then returned behind the screen; after a pause, a different object (e.g., a bottle) moved from behind the right edge of the screen and then returned behind the screen. The process was repeated until the infants had observed multiple emergences of each object. At that point, the screen was turned aside to reveal either one object (e.g., a ball) or two distinct objects (e.g., a ball and a bottle). The infants looked reliably longer at the two- than at the one-object display during both the introductory and the test trials. Xu and Carey took their results to suggest that the infants (a) did not realize that the featural differences between the objects that emerged on either side of the screen signaled the presence of two distinct objects and hence (b) found neither the one- nor the two-object test display surprising. The infants' test responses thus reflected only their intrinsic preference for the two- over the one-object test display (a preference suggested by the infants' introductory data). Similar results were obtained in additional experiments conducted with related event-mapping procedures (Xu and Carey, 1996; see also Leslie *et al.*, 1996, and Wilcox and Baillargeon, in press).

The negative findings of Xu and Carey (1996) contrast with positive results we obtained with 9.5- and 7.5-month-olds in experiments conducted with event-monitoring tasks (Wilcox and Baillargeon, in press). In one experiment, the infants first received familiarization trials in which a ball moved behind the left edge of a very wide screen that occluded the center and right portions of the apparatus; after a long pause, the ball reappeared at the screen's left edge and returned to its

²This is not to say that the habituation event was of no use to the infants; being familiar with the mouse and the habituation screen no doubt made it easier for the infants to focus on and reason about the opening in the test screen.

starting position. Following the familiarization trials, the very wide screen was replaced with a narrower test screen that occluded only the center portion of the apparatus. As before, the ball moved behind the left edge of the screen; after a pause, a box emerged at the screen's right edge and moved to the right. The entire sequence was then repeated in reverse. For half of the infants (wide-screen condition), the test screen was sufficiently wide to occlude the ball and box simultaneously; for the other infants (narrow-screen condition), the test screen was too narrow to occlude the two objects at once. The infants in the narrow-screen condition looked reliably longer during the test trials than did those in the wide-screen condition. These and control results indicated that the infants (a) were led by the featural differences between the ball and box to view them as distinct objects; (b) realized that the ball and box could both be occluded by the wide but not the narrow screen; and hence (c) were surprised in the narrow-screen condition when this judgment was contradicted.

The discrepancy between the results of Xu and Carey (1996) and our own results (Wilcox and Baillargeon, in press) can again be understood in terms of the different requirements associated with event-mapping and event-monitoring tasks. In order to be successful, the infants tested by Xu and Carey had to compare the one- or two-object test display before them to the preceding occlusion event. According to the present analysis, this comparison required the infants to retrieve a representation of the occlusion event, map it onto the test display before them, and determine whether the two were consistent. The infants we tested, on the other hand, had only to monitor the narrow- or wide-screen test event before them and judge whether successive portions of the event were consistent.

The research reviewed in this section suggests two conclusions. First, infants as young as 7.5 months of age are able to use featural information to individuate objects in different-objects occlusion events. Second, whether infants reveal this ability depends on the task that is used to assess it: event-mapping tasks yield less successful performances than do event-monitoring tasks.

The present research

The present research examined the responses of 7.5-month-olds (Experiment 1) and 4.5-month-olds (Experiment 2) to different-objects and same-object occlusion events. The infants were tested with an event-monitoring task adapted from that in our initial experiments (Wilcox and Baillargeon, in press).

There were two main reasons to carry out this research. The first was to confirm and extend our previous results with 9.5- and 7.5-month-olds (Wilcox and Baillargeon, in press). Recall that in these experiments infants were shown only different-object events; in the present research, however, as was noted above, infants were presented with both different-objects and same-object events. The second reason to conduct the present research was to ascertain whether younger, 4.5-month-old infants are also able to use featural information to individuate objects in occlusion events. The experiments reviewed above on same-object occlusion events suggest that, when tested with an event-monitoring task, young infants give evidence that they view such events as involving a single object (e.g., Aguiar and Baillargeon, 1997a, b; Baillargeon and DeVos, 1991; Baillargeon and Graber, 1987). However, the findings do not make clear what is the basis of infants' responses. Do infants compare the featural properties of the objects that appear on either side of the occluder and conclude that a single object is present when the properties are similar? Or do infants bypass any featural analysis of the objects and reach their conclusion on an entirely different basis, such as a comparison of the objects' motions? We reasoned that evidence that 4.5-month-olds respond differentially to different-objects and same-object occlusion events, even when they involve similar object motions, would help resolve this issue. Such results would indicate that, in the absence of unambiguous spatiotemporal information, infants as young as 4.5 months of age are capable of using featural information to determine how many objects are involved in an occlusion event.

Experiment 1

In a recent series of experiments, we found that, when tested with an event-monitoring task, 7.5-month-olds give evidence that they can use featural information to individuate the objects in a different-objects occlusion event (Wilcox and Baillargeon, in press). Experiment 1 was designed to confirm and extend these results. The infants were assigned to a ball-box or a ball-ball condition. The infants in the *ball-box* condition (see Figure 1) were first familiarized with the following event: a green ball resting at the left end of a platform moved to the right until it disappeared behind the left edge of a wide yellow screen; after a pause, a red box appeared at the screen's right edge and moved to the right end of the platform. The entire sequence was then repeated in reverse: the box returned behind the screen, and then the ball returned to its starting position at the left end of the

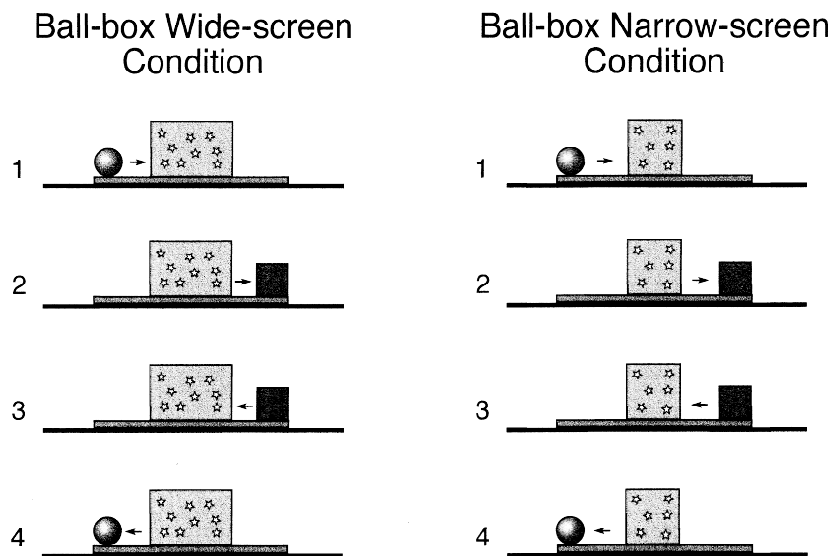


Figure 1. Schematic drawing of the test events in the ball-box narrow- and wide-screen conditions in Experiment 1.

platform. Following the familiarization trials, the infants saw a test event identical to the familiarization event, with one exception: the screen was replaced with one of two novel test screens. Both test screens were blue, decorated with stars, and shorter in height than the familiarization screen (these changes were intended to help the infants notice the introduction of the novel test screens). The only difference between the two test screens had to do with their widths. One screen (wide-screen condition) was of the same width as the familiarization screen and was sufficiently large to occlude the ball and box at the same time. The other test screen (narrow-screen condition) was narrower than the

familiarization and wide test screens; the width of the narrow test screen was in fact smaller than the combined width of the ball and box, so that it should have been impossible for the narrow screen to simultaneously occlude the two objects. The infants in the *ball-ball* condition (see Figure 2) saw the same familiarization and test events as the infants in the ball-box condition, except that the ball appeared on both sides of the screen.

Our reasoning was as follows. If the infants in the ball-box condition (a) were led by the featural differences between the ball and box to view them as distinct objects; (b) realized that the combined width of the ball and box relative to that of the screen determined

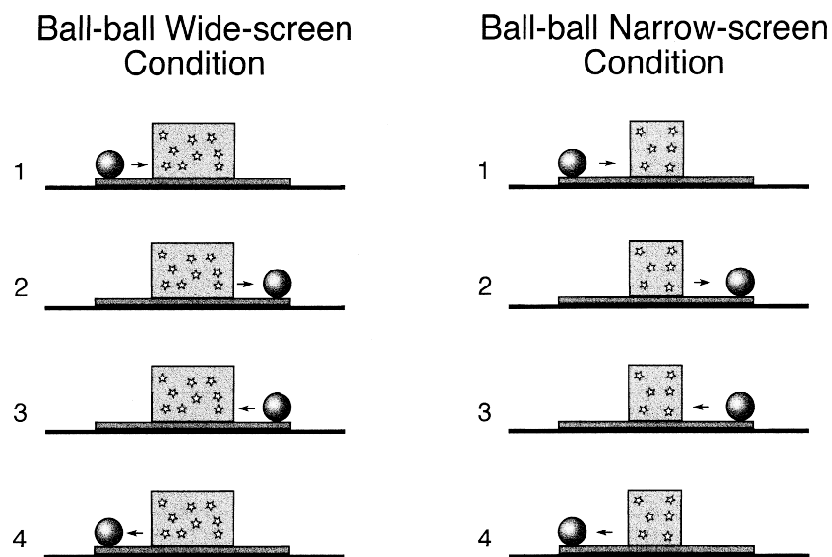


Figure 2. Schematic drawing of the test events in the ball-ball narrow- and wide-screen conditions in Experiment 1.

whether the two objects could be simultaneously occluded by the screen; and (c) judged that the ball and box could both be occluded by the wide but not the narrow screen, then the infants in the narrow-screen condition should be surprised when this judgment was violated. Because infants' surprise or puzzlement at an event typically manifests itself by prolonged looking at the event (Bornstein, 1985; Spelke, 1985), the infants in the narrow-screen condition should look reliably longer during the test trials than those in the wide-screen condition. Furthermore, if the infants in the ball-ball condition (a) assumed, based on the featural similarities between the balls that appeared on either side of the screen, that they were one and the same ball, and (b) recognized that the ball could be occluded by either the wide or the narrow screen, then the infants in the narrow- and wide-screen conditions should look about equally during the test trials.

Method

Participants

Participants were 26 healthy fullterm infants, 12 male and 14 female ($M = 7$ months, 18 days; range = 7 months, 2 days to 8 months, 4 days). Five additional infants were tested but eliminated; they failed to complete three valid test trials, three because of procedural problems, one because of fussiness, and one because the infant looked the maximum number of seconds allowed (60 s) on all familiarization and test trials. The infants were randomly assigned to the four experimental groups formed by crossing the two object conditions (ball-box versus ball-ball) and the two screen conditions (narrow versus wide): ball-box narrow-screen ($n = 6$, $M = 7$ months, 19 days); ball-box wide-screen ($n = 7$, $M = 7$ months, 26 days); ball-ball narrow-screen ($n = 6$, $M = 7$ months, 13 days); and ball-ball wide-screen ($n = 7$, $M = 7$ months, 13 days). In this and the next experiment, the infants' names were obtained from birth announcements in the local newspaper. Parents were contacted by letter and follow-up phone calls. Parents in Experiment 1 were offered reimbursement for their travel expenses but were not compensated for their participation.

Apparatus and stimuli

The apparatus consisted of a wooden cubicle 182 cm high, 100 cm wide, and 42 cm deep. The infant sat facing an opening 41 cm high and 94 cm wide in the front wall of the apparatus. The floor of the apparatus was covered with cream colored contact paper, and the

side and back walls were covered with patterned contact paper. A platform 1.5 cm tall, 60 cm wide, and 19 cm deep and covered with patterned contact paper lay 4.5 cm from the back wall, centered between the left and right walls; a 6 cm wide piece of light blue flannel lay length-wise down the center of the platform.

The screen used in the familiarization trials was 30 cm wide and 29 cm high; it was made of yellow cardboard and covered with clear contact paper. The wide test screen was 30 cm wide and the narrow test screen 21 cm wide; both screens were 21.5 cm high, were made of blue cardboard decorated with small gold and silver stars, and were covered with clear contact paper. The familiarization and test screens were all mounted on metal legs.

The ball was 10.25 cm in diameter, made from styrofoam, and painted green with evenly spaced red, blue, and yellow dots. The ball had a thin wooden stick (not visible from the infants' viewpoint) attached to its back that protruded through a slit in the back wall. This slit was 2 cm high and 48 cm wide, was located 7 cm above the apparatus floor, and was partly concealed by a cream-colored fringe. By moving the ball's stick along the slit, an experimenter could move the ball left and right along the platform. The experimenter's hand holding the stick was concealed from the infants' view by the ball, the back wall, and the fringe covering the slit; as an added precaution, the hand also wore a cream-colored glove that blended with the fringe.

The box was 11.75 cm square, made of cardboard, and covered with red felt decorated with evenly spaced silver thumbtacks.³ The box was open on its left side and also had an open channel in its back. After it moved behind the screen, the ball entered the box through its left open side; the ball's stick protruded through the channel at the back of the box and was used to move the box. The box was first rotated clockwise so that its open

³ Since the ball was 10.25 cm wide and the box 11.75 cm wide, the narrow screen, which was 21 cm wide, was only 1 cm narrower than the ball and box combined. It might be thought that such a small violation would have been impossible even for adults to detect reliably. Nevertheless, our positive results with 9.5- and 7.5-olds (Wilcox and Baillargeon, in press) were obtained using a 1-cm violation similar to the one used here. In addition, data collected with adult subjects (Wilcox and Baillargeon, in press) indicated that they not only readily perceived the narrow-screen violation, but believed it was several times greater than it actually was (see Figure 1). Subjects apparently assumed that the ball, rather than stopping abruptly as soon as it was out of sight, pursued its trajectory for some distance behind the screen; this of course contributed to the perception that the screen was too narrow to simultaneously hide the ball and box. In Experiment 2, a different process was used to produce the events that made it possible to present the infants in the ball-box narrow-screen violation with a larger, 5-cm violation.

side faced down; the box could then be moved to the right of the screen. Because the box's open side faced down, the opening was not visible to the infants when the box was in view. After it returned behind the screen, the box was rotated counter-clockwise and the ball was free to emerge from the box's open side.

To equate as much as possible the procedures used in the ball-box and ball-ball conditions, a 'fake' box was placed behind the screen in the ball-ball condition. This box was 11.75 cm square, made of light weight metal, and covered with red felt. The fake box had two open sides (right and left) and an open channel in the back so that the ball and its attached stick could move through the box.

A muslin-covered frame 61 cm high and 100 cm wide was lowered in front of the opening in the front wall of the apparatus at the end of each trial. Two wooden frames, each 182 cm high and 69 cm wide and covered with yellow cloth, stood at an angle on either side of the apparatus. These frames isolated the infants from the experimental room. In addition to the room lighting, two 20-watt fluorescent bulbs 59 cm long were affixed to the inside front wall of the apparatus.

Events

One experimenter produced the events. The numbers in parentheses indicate the time taken to produce the actions described. A metronome ticked softly once per second to help the experimenter adhere to the events' scripts.

Ball-box narrow-screen condition

Familiarization event At the start of each familiarization trial, the ball sat with its center 6 cm from the left end of the platform. The familiarization screen stood upright and centered in front of the platform, and the box sat behind the screen.

Each familiarization trial began with a brief pretrial during which the observers monitored the infant's looking at the ball until the computer signaled that the infant had looked for 1 cumulative second. After a 1-s pause, the ball moved behind the screen and entered the box, which was quickly rotated (2 s). The box then emerged from behind the screen and moved to the right until its center was 6 cm from the right end of the platform (2 s). After a 1-s pause, the box returned to its original position behind the screen and was again quickly rotated (2 s). The ball then emerged from the box and returned to its starting position at the left end of the platform (2 s). When in view, the ball and box

moved at a speed of about 12 cm per s; when out of view, the objects were moved slightly faster to allow time for the box's rotation. The 10-s event sequence just described was repeated continuously until the trial ended.

Test event The test event was identical to the familiarization event except that the familiarization screen was replaced with the narrow test screen.

Ball-box wide-screen condition

The familiarization and test events in the ball-box wide-screen condition were identical to those in the ball-box narrow-screen condition except that the narrow test screen was replaced with the wide test screen.

Ball-ball narrow- and wide-screen conditions

The familiarization and test events in the ball-ball narrow- and wide-screen conditions were identical to those in the ball-box narrow- and wide-screen conditions, respectively, with two exceptions. First, the ball, rather than the box, emerged to the right of the screen. Second, to prevent infants and observers from distinguishing between the ball-box and ball-ball conditions on the basis of faint noise cues associated with the lifting and lowering of the box (when rotated) in the ball-box condition, the fake box was used. After moving behind the screen, the ball entered the fake box, which was then quickly lifted and lowered; the ball then exited the fake box through its other open side.

Procedure

The infant sat on a parent's lap centered in front of the apparatus. The infant's head was approximately 78 cm from the objects on the platform. The parent was asked not to interact with the infant while the experiment was in progress and to close his or her eyes during the familiarization and test trials.

Each infant participated in a two-phase procedure that consisted of a familiarization and a test phase. During the *familiarization* phase, the infants saw the familiarization event appropriate for their condition on six successive trials. Each trial ended when the infant (a) looked away for 2 consecutive seconds after having looked at the event for at least 5 cumulative seconds (beginning at the end of the pretrial) or (b) looked for 60 cumulative seconds without looking away for 2 consecutive seconds. During the *test* phase, the infants saw the test event appropriate for their condition on three successive trials. The criteria used to terminate the

test trials were the same as for the familiarization trials. The 5-s minimum value was chosen to ensure that the infants had the opportunity to observe the box or ball emerge to the right of the screen.

The infant's looking behavior was monitored by two observers who watched the infant through peepholes in the cloth-covered frames on either side of the apparatus. The observers were not told, and could not determine, to which condition each infant was assigned.⁴ Each observer held a button connected to a DELL computer and depressed the button when the infant attended to the events. The looking times recorded by the primary observer were used to determine when a trial had ended. Each trial was divided into 100-ms intervals, and the computer determined in each interval whether the two observers agreed on the direction of the infant's gaze. Interobserver agreement was measured for 25 of the infants (only one observer was present for one of the infants) and was calculated for each test trial on the basis of the number of intervals in which the computer registered agreement, out of the total number of intervals in the trial. Agreement averaged 94% per test trial per infant.

Preliminary analysis of the infants' mean looking times during the test trials did not yield a significant Sex \times Object Condition (ball-box versus ball-ball) \times Screen Condition (narrow versus wide) interaction, $F(1, 18) = 0.05$; the data were therefore collapsed across sex in subsequent analyses.⁵

Results

Familiarization trials

The infants' looking times during the six familiarization trials (see Figure 3) were averaged, as in Wilcox and Baillargeon (in press), and compared by means of a 2×2 analysis of variance (ANOVA), with Object Condition (ball-box versus ball-ball) and Screen Condition (narrow versus wide) as between-subjects factors. The main effects of object condition, $F(1, 22) = 1.38$,

⁴The infants in Experiments 1 and 2 were presented with test events in which a ball or a ball and box appeared on either side of a screen. For all 54 infants in these experiments, the primary experimenter was asked at the end of each test session whether the infant had seen the same object or different objects on the two sides of the screen. The primary observer guessed correctly for only 30/54 infants, a performance not significantly different from chance (cumulative binomial probability, $p > 0.05$).

⁵Because of the small number of infants in each Sex \times Object Condition \times Screen Condition cell, this analysis needs to be interpreted with caution. The same caveat applies to the sex analysis in Experiment 2, which also yielded negative results.

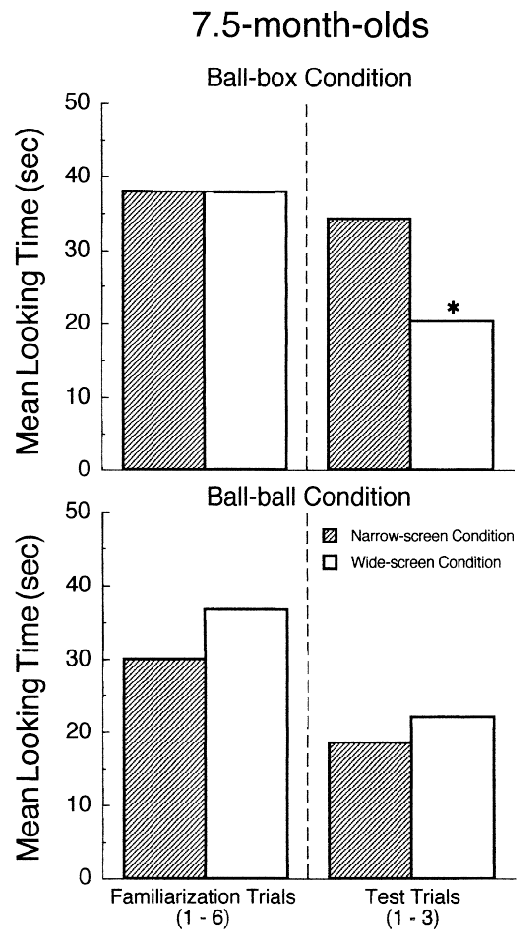


Figure 3. Mean looking times of the infants in Experiment 1 during the familiarization and test trials.

and screen condition, $F(1, 22) = 0.77$, were not significant, both p 's > 0.05 . In addition, the Object Condition \times Screen Condition interaction was not significant, $F(1, 22) = 0.72$, indicating that the infants in the four different conditions did not differ reliably in their mean looking times during the familiarization trials (ball-box narrow-screen, $M = 37.8$, $SD = 6.8$; ball-box wide-screen, $M = 38.0$, $SD = 10.9$; ball-ball narrow-screen, $M = 30.0$, $SD = 10.9$; and ball-ball wide-screen, $M = 36.7$, $SD = 10.1$).

Test trials

The infants' mean looking times during the three test trials (see Figure 3) were averaged and analyzed in the same fashion as the familiarization trials. The main effects of object condition, $F(1, 22) = 3.52$, and screen condition, $F(1, 22) = 1.90$, were not significant, both p 's > 0.05 . However, the Object Condition \times Screen