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Beyond the search barrier: A new task for assessing object individuation in young infants

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ABSTRACT

Object individuation, the capacity to track the identity of objects when perceptual contact is lost and then regained, is fundamental to human cognition. A great deal of research using the violation-of-expectation method has been conducted to investigate the development of object individuation in infancy. At the same time, there is a growing need for converging methods of study. Reported here are data obtained with from a newly developed search task that can be used with infants as young as 5 months of age. The results suggest that this method is a sensitive measure of object individuation in young infants and demonstrate the advantages of using converging methods of study.

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The visual world provides a wealth of information about objects. However, as objects and observers move about in the world, visual contact is often lost and then regained, presenting observers with the challenge of determining whether an object currently in view is the same object or a different object than seen previously. Over the last 15 years, a substantial number of studies have been conducted to investigate the development of object individuation in infancy. Most of these studies have employed the violation-of-expectation (VOE) method, which is often used to assess cognitive development in motorically limited, pre-verbal infants. For example, in one task infants saw a box (box–ball event) or a ball (ball–ball event) disappear behind one edge of a wide-screen and, after an interval appropriate for the objects' rate of motion, a ball appeared at the other edge. The screen was then lowered to reveal a single object, the ball, at the right end of the platform. Infants 5.5–11.5 months show prolonged looking to a one-object display after having viewed a same-features (box–ball) than different-features (ball–ball) event, suggesting that the infants used the featural differences to infer that two distinct objects were involved in different-features event and found the one-object display inconsistent with this interpretation (Wilcox & Baillargeon, 1998a; Wilcox & Schweinle, 2002).

Investigations using this and other VOE tasks have revealed a number of theoretically important findings, ranging from developmental hierarchies in the kind of information to which infants are most sensitive (Káldy & Leslie, 2005; Krojgaard, 2004; Spelke, Kestenbaum, Simons, & Wein, 1995; Tremoulet, Leslie, & Hall, 2001; Wilcox & Baillargeon, 1998a,b; Wilcox & Schweinle, 2003; Wilcox, 1999; Woods & Wilcox, 2006; Xu & Carey, 2001) to the role of language and conceptual development in the individuation process (Xu, 2002, 2007; Xu, Cote, & Baker, 2005). As new findings emerge, there continues to be a need for converging methods of study. Convergent methods allow investigators to establish the validity of novel, and sometimes controversial, findings. Convergent methods also allow researchers to test hypotheses that are not easily assessed using

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looking behavior, and might lend themselves better to a different response domain. There are number of researchers who have developed innovative and creative methods for substantiating VOE findings obtained in other cognitive domains (e.g., Clifton, Rochat, Litvsky, & Perris, 1991; Feigenson & Carey, 2003; Goubet & Clifton, 1998; Hespos & Baillargeon, 2006; Hofstadter & Reznick, 1996; Hood & Willatts, 1986; Kerstin & von Hofsten, 2004; Ruffman, Slade, & Redman, 2005; Wang & Kohne, 2007) but to date, converging methods that can be used to investigate object individuation in young infants have yet to be established.

One alternative method that investigators have used to assess object individuation in older infants is the search method (Van de Walle, Carey, & Prevor, 2000; Xu & Baker, 2005). For example, in Xu and Baker (2005) 10-month-olds saw an event in which one object (e.g., a cup) was removed from a box and then returned. After two or more emergences of the object, infants were allowed to search in the box. For some infants, the object (e.g., the cup) remained in the box and for other infants the object was surreptitiously replaced with a different object (e.g., a duck). The infants who retrieved the duck rather than the cup after reaching into the box were more likely to continue searching in the box than the infants who retrieved the cup, suggesting that they used the featural differences between the cup and the duck to determine that they were two separate objects and concluded that the box still contained the cup. Using this method, Van de Walle et al. (2000) and Xu and Baker (2005) were able to assess the validity of VOE findings and to further explore older infants' capacity to individuate objects.

One limitation of such search tasks, however, is that they are difficult to implement with younger infants. Typically, search methods present task demands that prevent infants younger than about 9 months from successfully searching for hidden objects, even though it is clear from data collected using other methods, such VOE, eye-tracking, and reaching-in-the-dark (e.g., Baillargeon, 1998, 2004; Clifton et al., 1991; Hood & Willatts, 1986; Johnson, Amso, & Slemmer, 2003; Von Hofsten, Kochukhova, & Rosander, 2007) that young infants have an understanding of object permanence. The goal of the present research was to develop a simplified search task that could be used with infants as young as 5 months. This is the age at which infants begin to sit with limited support and direct reaching towards visible objects (Rochat, 1992; Rochat & Goubet, 1995), yet fail to remove covers or occluders to obtain hidden objects.

In developing a simplified search task, we chose to use occlusion sequences similar to those used in VOE tasks. More specifically, we used the box–ball and ball–ball events of Wilcox and Baillargeon (1998a). The main difference between the Wilcox and Baillargeon task and the current task is that in the former the dependent measure was duration of looking and in the latter the dependent measure is duration of searching. In order to decrease the response demands typically associated with search methods, the occluder was made of fringed-cloth, so that infants could easily reach (but not see) through the screen.

Infants aged 5–7 months were tested in a two-phase task. In the initial phase (Fig. 1), infants saw an event in which a box (box–ball condition) or a ball (ball–ball condition) moved behind the left edge of a wide-screen made of cloth fringe and a ball emerged from the right edge. In the final phase of the task, the platform was pushed forward so that the screen was directly in front of the infant and the infant was allowed to search. The task was designed so that during the final phase the infant was closer to the fringed-screen than the ball at the end of the platform. This was to prevent infants from simply reaching for the ball and engaging in object play and, instead, to facilitate search behavior. Although we could have allowed infants to retrieve the ball and then take it away, as was done by Van de Walle et al. (2000) and Xu and Baker (2005) with older infants, pilot data suggested that this procedure made for a longer testing session and often distressed the infants, leading to higher attrition rates. Given the design of the task, predictions are framed in terms of the location, the ball or the fringed-screen, to which infants will reach most often. If infants perceive the occlusion sequence as involving two distinct objects, one of which is hidden behind the screen, they should reach more to the fringed-screen than to the visible ball. In contrast, if infants perceive the occlusion sequence as involving a single object, they should reach more to the visible ball than to the screen (since the screen does not hide an object). Finally, if infants fail to use featural information to draw conclusions about the number of objects involved in the event, they should reach about equally to the fringed-screen and the ball.

1. Method

1.1. Participants

Thirty infants, 19 males (M = 6 months, 11 days; range = 5 months, 10 days to 7 months, 15 days). Parents reported their infant's race/ethnicity as Caucasian (N = 24), Hispanic (N = 4), or Black (N = 2). Six of the 30 infants contributed only one of

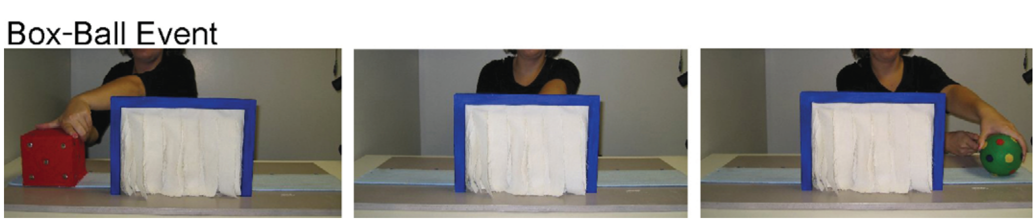

Fig. 1. The box–ball occlusion event. After the ball stopped at the right edge of the platform, the platform was pushed forward and the infant was allowed to search. In the ball–ball event, the ball was seen to both sides of the screen.

two test trials because of failure to watch the occlusion sequence ($N = 3$), failure to engage in reaching behavior ($N = 1$), or procedural problems ($N = 2$). An additional 3 infants were tested but eliminated from analysis because of failure to watch the occlusion sequence ($N = 1$), failure to engage in reaching behavior ($N = 1$), or procedural error ($N = 1$). Fifteen infants were randomly assigned to each condition.

1.2. Apparatus

The apparatus was a table (122 cm × 94 cm) with a rectangular section (13 cm × 18 cm) cut out of one side. The occlusion event was conducted on a platform (80 cm × 40 cm). A strip of flannel lay lengthwise down the center of the platform to allow for smooth movement of the objects. The screen was 30 cm × 22 cm and made of a blue wooden frame to which four layers of fringed-muslin were attached; the layers overlapped so that the area behind the screen was not visible. The screen was anchored into the platform on wooden pegs and placed in front of the flannel, equidistant from the right and left edges of the platform.

The ball was 10.25 cm in diameter and green with red, blue, and yellow dots. A wooden dowel protruded from the back of the ball so it could be easily moved across the platform and removed from the box (see below). The box was 12 cm square, red, and decorated with silver metal tacks. The bottom of the box was open and the inside was hollow to allow for insertion of the ball. The “fake” box used in the ball–ball condition (see below) was similar in appearance to the “real” box except that both sides of the box were open and a slit was cut across the back of the box, so that the ball could pass through the box.

1.3. Conditions

Box–Ball Condition. At the start of each test trial infants saw the box at the left edge of the platform. Once the infant looked at the box (1 s), the box moved along the platform until it become fully occluded behind the left edge of the screen (3 s). After a brief pause (1 s), the ball emerged from behind the right edge of the screen and moved to the right edge of the platform (3 s) where it came to rest (1 s). The box–ball event was produced by placing the ball inside the box prior to the start of the trial (out of the infants’ view); the box was moved by grasping the dowel attached to the ball (which was inside the box). When behind the screen, the box was quickly rotated, so that the open bottom was facing right and the ball moved out of the box and into view from behind the right edge of the screen. When visible, the objects moved at a rate of 12 cm/s.

Ball–Ball Condition The test event of the ball–ball condition was identical to the box–ball event condition except that infants saw a ball to both sides of the screen. To equate the two events as much as possible, the “fake” box was placed behind the screen before the start of each test trial; the ball was moved into and out of the box when behind the screen.

1.4. Procedure

The infant sat in a parent’s lap in the rectangular cut out across the table from the experimenter. Parents were instructed to refrain from interacting with their infant during the test session. The experimenter who presented the familiarization and test events was blind to the research hypotheses. Because pilot data indicated that infants were unlikely to engage in reaching behavior during the test trials if they were not first acquainted with the apparatus and the fringed-screen, infants were presented with three familiarization trials designed to acquaint them with the experimental situation and to assess the extent to which they were willing and able to engage in the search task. Similarly, Van de Walle et al. (2000) found that familiarization trials were critical to the performance of older infants in their search task. In the first familiarization trial, infants were shown the fringed-screen and were encouraged to reach through the fringe. If necessary, the experimenter gently guided the infant’s hand through the fringed-screen. Once the infant placed his or her hand through the fringed-screen twice, the trial ended. In the second familiarization trial, infants saw a small toy (a yellow squeaky lion) sitting at the left edge of the platform: the experimenter squeaked the lion to attain the infant’s attention. Next, the lion move to the right along the platform until it was fully hidden behind the screen. Finally, the screen was pushed forward so that it sat directly in front of the infant and the infant was allowed to search for 20 s. If the infant failed to search for the hidden toy after 5 s, the following steps were taken in 5 s increments: the toy was pushed forward to create a bulge in the fringe; the toy was pushed further forward so that one-half of the toy was visible; the toy was pushed all the way through the fringe so that it was fully visible. Once the infant retrieved the toy, the trial ended. The third familiarization trial was identical to the first except that the yellow squeaky lion was replaced with a red and blue rattle.

Following the three familiarization trials, infants were presented with two test trials. Each test trial had two phases. In the first phase, infants saw the occlusion sequence (box–ball or ball–ball) appropriate for their condition. Once the ball came to rest at the right edge of the platform, the platform was pushed forward until the edge of the platform was directly in front of, and within easy reach of, the infant. In the second phase, the infant was allowed to search for 20 s. Since we were interested in persistence of infants’ search behavior, the object behind the fringed-screen was positioned so that infants would not be able to retrieve the object through the fringed-screen. During the search phase the experimenter looked down at the table directly in front of her with a neutral expression. After 20 s the platform was pulled back (away from the infant) to its starting position.

1.5. Coding of behavior

The test session was video-taped and infants' behaviors were later coded by naïve observers using Noldus ObserverPro. Familiarization trial 1 was not coded because the purpose of this trial was to simply acquaint the infant with the experimenter and the fringed-screen and all infants placed their hand through the screen twice in the first familiarization trial. Infants' reaching behaviors during the second and third familiarization trials were coded in regards to the degree of facilitation needed in order for the infant to obtain the toy. Each infant received a score of 1–4 on the basis of whether the infant retrieved the toy when it was fully occluded (1), created a bulge in the fringe (2), one-half visible (3), or fully visible (4). Although the main purpose of the familiarization trials was to acquaint the infants with the search task, coding and analysis of familiarization data allowed us to assess whether the infants in the two conditions differed initially in the extent to which they were willing or able to engage in the search task.

The occlusion (first) phase and the search (second) phase of the test trials were coded separately. During the 9 s occlusion phase, infants' looking times to the occlusion event were coded. Trials were excluded from the analysis if infants' looking times during the occlusion phase were <6 s. Of a possible of 60 trials (30 infants, 2 trials each), three infants contributed only one trial because of low looking times.

During the 20 s search phase, two aspects of infants reaching behavior were coded: duration of reaching and frequency of reaching. Duration of reaching was defined as the amount of time infants spent touching and reaching through the fringed-screen or reaching for the ball at the end of the platform during each trial. Frequency of reaching was defined as the number of times infants touched or reached to the fringed-screen or ball during each trial. Previous research conducted with older infants indicates that duration and frequency measures typically yield identical results, but that duration measures tend to be more robust (Van de Walle et al., 2000; Xu & Baker, 2005).

A reach to the ball was defined as a deliberate extension of the arm (more than 90° extended) with the fingers outstretched and pointing in the direction of the ball. Because the task was designed so that the ball was out of the infant's reach, infants rarely made contact with the ball. Because the screen was within easy reach of the infants, reaching to the screen was defined by any contact between an infant's fingers or hand and any part of the screen. This including reaching through the fringe, lifting the fringe, and making contact with the frame of the screen. Rarely, infants reached for the screen and the ball at the same time and this behavior was coded as "both" (the time was attributed to both the ball and the screen). Because the amount of time infants engaged in simultaneous reaching was minimal (box–ball condition $M = 2.45$ s, $SD = 3.43$ and ball–ball condition $M = 1.81$ s, $SD = 2.48$) and did not vary significantly by event, $t < 1$, $df = 28$, this factor will not be considered further. Finally, the direction of the infants' first reach (to the screen or to the ball) was coded.

Twenty-eight of the 30 infants tested were coded by a second naïve independent observer and inter-observer reliabilities averaged 97% (range = 89–99%)

2. Results and discussion

2.1. Familiarization trials

Two analyses were conducted on infants' reaching behavior during the second and third familiarization trials. First, search scores were averaged and analyzed by means of a mixed-model analysis of variance (ANOVA) with trial (trial 2 or 3) as the within-subjects factor and condition (box–ball or ball–ball) as the between-subjects factor. The analysis revealed no significant main effect of trial, $F(1,28) < 1$, or condition, $F(1,28) < 2.2$, nor an interaction between the two, $F(1,28) < 1$, indicating that the mean familiarization scores of the infants in the box–ball ($M = 3.44$ s, $SD = 0.82$) and the ball–ball ($M = 3.00$ s; $SD = 1.0$) condition did not vary reliably. Second, search scores for each trial were subjected to a chi-square analysis which revealed that the two groups did not differ reliably in their distribution of scores (Table 1) for familiarization trial 2, $\chi^2 = 1.40$, $df = 3$, $p > .05$ or familiarization trial 3, $\chi^2 = 2.19$, $df = 3$, $p > .05$.

Table 1
Crosstabulation of familiarization scores.

Score	Familiarization trial 2			Familiarization trial 3		
	Event		Total	Event		Total
	Box–ball	Ball–ball		Box–ball	Ball–Ball	
1	0	1	1	0	1	1
2	3	4	7	3	5	8
3	3	2	5	4	4	8
4	9	8	17	8	5	13
Total	15	15	30	15	15	30

Note: Each cell contains the number of infants who obtained that score for that familiarization trial (1 = toy was fully occluded, 2 = toy made bulge in the fringed-screen, 3 = toy was one-half visible, 4 = toy was fully visible). The distribution of scores did not vary significantly by condition (see text).

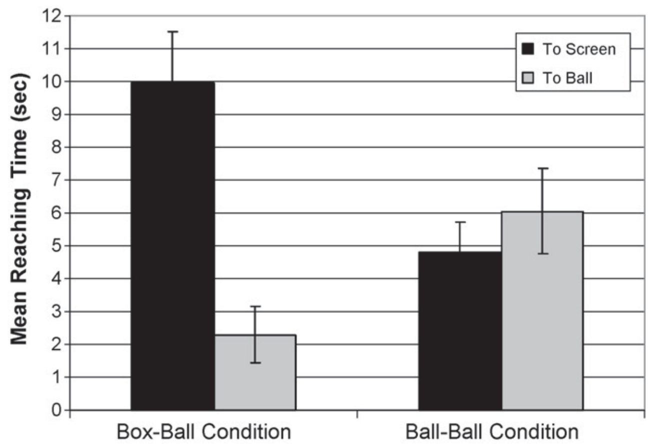

Fig. 2. Mean reaching times (and standard errors) to the screen and the ball for infants in the box–ball and the ball–ball conditions.

2.2. Test trials

2.2.1. Phase 1: occlusion

Infants' looking times during the Phase 1 of the two test trials were averaged and analyzed by means of a one-way ANOVA with condition (box–ball or ball–ball) as the between-subjects factor. The looking times of the infants in the box–ball (M = 8.60 s; SD = 0.62) and the ball–ball (M = 8.70 s; SD = 0.63) conditions did not differ reliably, $F(1,28) < 1$.

2.2.2. Phase 2: search

Infants' duration of reaching to the screen and the ball during Phase 2 of the test trials (Fig. 2) was averaged over the two trials and analyzed by means of a mixed-model ANOVA with reach location (screen or ball) as the within-subjects' factor and condition (box–ball or ball–ball) as the between-subjects' factor. The main effect of condition was not significant, $F(1,28) < 1$. The main effect of location was significant, $F(1,28) = 4.67$, $p < .05$, as was the location × condition interaction, $F(1,28) = 9.06$, $p < .01$, $\eta_p^2 = .25$. Planned comparisons revealed that the infants in the box–ball condition (M = 9.96 s, SD = 6.09) spent significantly more time reaching for the screen than the infants in the ball–ball condition (M = 4.81 s, SD = 3.34), $t = 2.84$, $df = 28$, $p < .01$. In contrast, the infants in the ball–ball condition (M = 6.06 s, SD = 5.09) spent significantly more time reaching for the visible ball than the infants in the box–ball condition (M = 2.30 s, SD = 3.34), $t = 2.39$, $df = 28$, $p < .025$. Finally, the infants in the box–ball condition spent significantly more time reaching for the screen than the box, $t = 3.44$, $df = 14$, $p < .01$. Note that the infants in the box–ball (M = 14.71 s, SD = 4.21) and the ball–ball (M = 12.68 s, SD = 4.36) condition spent about the same amount of time, overall, engaged in reaching behavior during the test trials, $t < 1.3$, $df = 28$, even though the location to which they searched differed.

Infants' frequency of reaching to the fringed-screen and the ball were analyzed in a similar manner. The main effects of condition and location were not significant, $F(1, 28)$s < 1. The location × condition interaction was significant, $F(1,28) = 12.71$, $p = .001$, $\eta_p^2 = .31$. Planned comparisons revealed that the infants in the box–ball condition (M = 4.93 s, SD = 1.87) reached more frequently to the screen than the infants in the ball–ball condition (M = 2.53 s, SD = 1.85), $t = 3.54$, $df = 28$, $p = .001$. In contrast, the infants in the ball–ball condition (M = 4.40 s, SD = 2.95) reached more frequently to the visible ball than the infants in the box–ball condition (M = 1.73 s, SD = 2.58), $t = -2.64$, $df = 28$, $p < .025$. Finally, the infants in the box–ball condition had a greater number of reaches to the screen than the ball, $t = 3.45$, $df = 14$, $p < .01$.

Finally, we examined the location of infants' first reach for each trial. There were 27 data points for each condition (three infants in the box–ball condition and three infants in the ball–ball condition contributed only one trial). In the box–ball condition, first reach was to the screen on 23/27 trials (85%), with a binominal probability of $p < .001$. In the ball–ball condition, first reach was to the ball on 19/27 trials (70%), with a binomial probability of $p < .025$.

2.2.3. Additional results

One might be concerned that infants found the box, seen to the left of the screen in the box–ball condition, more interesting than the ball, seen to the left of the screen in the ball–ball condition. Furthermore, the infants in both conditions may have inferred that the object seen to the left of the screen stayed behind the screen and, because they preferred the box over the ball, the infants in the box–ball condition reached more to the screen. To examine this possibility, a control study was conducted to assess infants' preference for the box and the ball. Infants (N = 15, 7 males, M age = 6 months, 4 days; range = 5 months, 24 days to 7 months, 3 days) watched as the ball and the box were placed simultaneously on the platform, the platform was pushed forward, and infants were allowed to reach. (The screen was not present on the platform.) Infants were presented with two trials and the position of the box and the ball was reversed on the second trial. Seven infants saw the box on the left in trial 1 and eight saw the ball on the left in trial 1. The object to which the infants reached and the latency of the reach was recorded for each trial. The infants chose the box and the ball an equal number of times (15 of 30 possible trials). In addition, the latency to reach to the box ($M = 0.62$ s, $SD = 0.98$) and the ball ($M = 0.94$ s, $SD = 1.21$) did not differ significantly, $t < 1$. These data suggest that the pattern of results obtained in this experiment cannot be explained by a preference for the box or the ball.

In summary, the infants in the box–ball condition directed their reaching to the fringed-screen whereas the infants in the ball–ball condition directed their reaching to the ball. This outcome suggests that (1) the infants in the box–ball condition interpreted the occlusion sequence as involving two distinct objects, one of which remained hidden behind the screen at the end of the event and (2) the infants in the ball–ball condition interpreted the test event as involving a single object, the ball which came to rest at the end of the platform. Other results, which eliminate alternative reasons for group differences in reaching behavior, support this interpretation of the data. For example, the box–ball and the ball–ball infants were similar in their search abilities (i.e., the groups did not differ in the amount of facilitation required to retrieve the toy in the familiarization trials). In addition, the box–ball and the ball–ball infants were similar in their willingness to engage in reaching during the test trials (i.e., the two groups did not differ in the amount of time they spent reaching during the search phase of the test trials, even though the location to which they reached did differ). Finally, the box–ball and the ball–ball infants looked almost continuously during the occlusion sequence, indicating that both groups had ample time to view the occlusion event.

One might be concerned that the infants simply found the box–ball occlusion sequence more interesting than the ball–ball sequence, leading to more activity during the second phase of the search task, most of which was directed towards the screen. However, two data points argue against this interpretation. The infants in the box–ball and the ball–ball condition looked about equally during the occlusion sequence (Phase 1 of the test trial) and spent about the same amount of time, overall, engaged in reaching behavior when allowed to search (Phase 2 of the test trial). Hence, the box–ball infants' longer duration of screen-directed behavior cannot be explained by greater interest in (and hence greater action in response to) one occlusion sequence than another.

3. General discussion

The present research used a simplified search task to assess infants' interpretation of different-features (box–ball) and same-features (ball–ball) occlusion events. The results revealed that after viewing a box–ball occlusion sequence, infants directed their reaching behavior to the fringed-screen rather than the visible ball, suggesting that they interpreted the event as involving two distinct objects, one of which was hidden behind the screen. In contrast, after viewing the ball–ball occlusion sequence, infants directed their reaching behavior to the visible ball, suggesting that they interpreted the event as involving only a single object, the visible ball. These results are consistent with those obtained using violation-of-expectation methods (e.g., Wilcox & Baillargeon, 1998a,b; Wilcox & Schweinle, 2002) and provide converging evidence for the conclusion that young infants draw on featural information to individuate objects. These results also suggest that this simplified search task is a reliable method with which to investigate object individuation in motorically limited, pre-verbal infants.

In addition, these results build on previous VOE findings and illustrate advantages of using converging methods of study. For example, in previous VOE investigations of infants' interpretation of different- and same-features events (Wilcox & Baillargeon, 1998a; also see Wilcox & Schweinle, 2002), infants were presented with a box–ball or ball–ball occlusion sequence similar to that presented to the infants in the present experiment. Following the occlusion sequence, the screen was lowered to reveal only the ball at the right end of the platform (infants were not allowed to reach). The infants in the box–ball condition showed prolonged looking to the one-ball display, suggesting they found the one-ball display inconsistent with their interpretation of the box–ball occlusion sequence. In contrast, the infants in the ball–ball condition did not show prolonged looking to the one-ball display. The ball-ball data are more difficult to interpret. One possible explanation for this pattern of results is that the infants interpreted the ball–ball event, as it unfolded before them, as involving a single ball. Hence, when the screen was lowered the infants found the final one-ball display expected. An alternative explanation is that infants interpreted the ball–ball event as involving two identical balls but recognized, once the screen was lowered, that the event could have been produced with a single ball. So although their initial interpretation of the event included two identical balls, they did not find the presence of a single ball surprising. The reaching data allow us to distinguish between these two interpretations of the looking-time data. The fact that the infants in the same-features condition directed a longer duration of reaching, and significantly more first reaches, to the ball than to the fringed-screen, and that the infants in the same-features condition demonstrated significantly more reaching to the ball than the infants in the different-features condition, suggests that the infants interpreted the ball–ball event as involving a single ball. Hence, the present results help to clarify those obtained with VOE methods.

These results are also consistent with those of researchers using search tasks with older infants. For example, Xu and Baker (2005) reported that 10-month-olds used featural information to individuate objects in a search task. The present results build on these findings by demonstrating that, when made sufficiently simple, search tasks can be used with infants as young as 5 months. The development of alternative methods for use with younger infants has become more pressing as VOE methods continue to reveal theoretically important changes in infants' capacity to individuate objects between 5.5 and 10.5 months of age (e.g., Wilcox & Woods, 2009; Xu, 2007). Alternative methods can serve to substantiate these findings and to test hypotheses that are more difficult to assess using looking behavior. To be clear, we are not suggesting that VOE methods yield spurious and unreliable results. Instead, we are suggesting that within any field of study convergent methods are critical to the advancement of knowledge. The method developed here can be easily adapted to study other aspects of object individuation (Smith & Wilcox, 2009).

Finally, these findings also have much broader impact. One of the greatest puzzles of cognitive development is why younger infants, when tested with violation-of-expectation tasks, demonstrate object permanence (i.e., the understanding that objects continue to exist when hidden). Yet, when search tasks are employed, infants younger than 8 months fail to demonstrate this capacity. One interpretation that has been offered for this dissociation is that young infants' representations of hidden objects are relatively weak and can drive looking but not reaching behavior (Munakata, 2001; Shinskey & Munakata, 2005). According to this interpretation, infants gradually develop stronger representations that are sufficiently robust to support performance on search tasks. An alternative interpretation is that this dissociation arises from the greater cognitive demands associated with search tasks and/or infants' limited flexibility in applying problem solving strategies (Aguiar & Baillargeon, 2000; Keen, Carrico, Sylvia, & Bertheir, 2003; Luo, Baillargeon, Brueckner, & Munakata, 2003). According to this interpretation, it is not the strength of the representation but task demands that limit performance on search tasks (Keen, 2003). The present results suggest that when task demands are minimal (successful performance requires only a direct reach through the fringe) young infants search reliably for hidden objects. The charge of future research will be to identify the cognitive demands that limit infants' performance on search tasks and the extent to which these demands are observed in the natural environment.

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