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Perception of Object Unity in 2-Month-Old Infants

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The perception of object unity in partial occlusion displays was examined in 72 2-month-old infants. The infants were habituated to 1 of 3 displays depicting a rod undergoing lateral motion behind a box. In each display, more of the rod was visible behind the box than was previously available in prior studies of young infants' perception of occlusion. Posthabituation test displays consisted of 2 rod pieces (broken rod) and a complete rod, presented 3 times each in alternation. Infants in all 3 conditions looked longer at the broken rod than at the complete rod, suggesting that the hidden region of the rod in the habituation display was inferred despite the absence of direct perceptual support. These findings suggest that very young infants' visual, attentional, or cognitive skills may be insufficient to consistently support perception of object unity, except under some display conditions.

Adults experience a world filled with objects that are often partially hidden from view. Yet adults have no particular difficulty perceiving the coherence of partially occluded objects. The origins of this ability have been a topic of considerable interest, beginning with the observations of Piaget (1952, 1954). He proposed that young infants do not conceptualize objects as existing behind occluders until they have had extensive experience observing and manipulating objects over the first 18 to 24 months of life.

Research conducted over the past decade provides strong evidence that Piaget (1952, 1954) underestimated the conceptual abilities of young infants. Studies by Baillargeon and her colleagues (e.g., Baillargeon, 1987; Baillargeon & DeVos, 1991; Baillargeon, Spelke, & Wasserman, 1985) have demonstrated that infants as young as 4 months of age often represent the existence and location of objects even under conditions of complete object occlusion. Moreover, S. P. Johnson and Náñez (1995), Kellman and Spelke (1983), Kellman, Spelke, and Short (1986), and Slater et al. (1990) found evidence of 4-month-olds' perception of the unity (connectedness) of objects whose centers are occluded.

In these latter studies, infants were shown a moving rod whose center portion was occluded by a box, until habituation of looking occurred (see Figure 1). The infants then viewed test displays consisting of a complete rod or two rod pieces with a visible gap corresponding to the location of the box in the habituation displays (broken rod). The infants typically looked longer at the broken rod than at the complete rod, suggesting that the hidden connectedness of the rod behind the box in the first display was perceived. This interpretation is based on the observation that infants tend to prefer a stimulus that is novel in comparison with an habituation stimulus. In this case, the complete rod did not elicit as much interest as the broken rod and was thus inferred to be relatively familiar to the infants.

This pattern of results, obtained under a variety of conditions, seems rather robust in 4-month-olds. For example, Kellman and Spelke (1983) and Slater et al. (1990) found that two rod pieces were perceived as connected when undergoing common lateral translation. Kellman et al. (1986) found perception of the unity of two rod pieces that moved vertically or in depth. S. P. Johnson and Náñez (1995) found perception of object unity when the displays were presented on a two-dimensional screen, in the absence of three-dimensional depth cues such as binocular disparity and motion parallax.

However, these findings do not necessarily inform us about the origins of perception of object unity. Kellman and Spelke (1983; see also Spelke, 1985, 1988) suggested that perception of partly occluded objects is rooted in an unlearned conception of the world. In their view, humans may begin life with a tendency to experience objects as coherent, independent, and persisting over time. Although the findings of the object unity studies cited in the previous paragraph are consistent with this view, it is possible that development occurring over the first 4 months is necessary for the abilities underlying perception of object unity.

Slater et al. (1990), Slater, Johnson, Brown, and Badenoch (in press), and Slater, Johnson, Kellman, and Spelke (1994) reported evidence in support of this latter view. In these studies, neonates consistently preferred to look at the complete rod as opposed to the broken rod after habituation, a response pattern opposite to that shown by 4-month-olds. This seems to indicate that neonates do not perceive object unity under these conditions. It is possible that very young infants do not make perceptual inferences from visual input, but rather only respond to what they see directly (Slater et al., 1990).

Taken together, these studies suggest that perception of object

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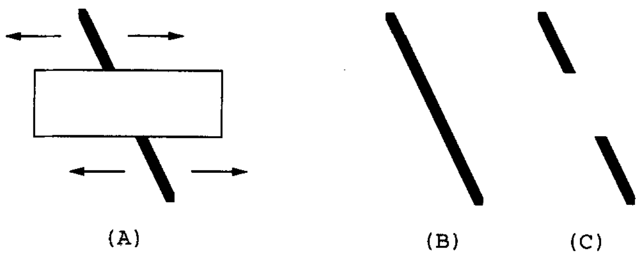

Figure 1. Examples of displays typically used in object unity studies: (A) rod-and-box (habituation) display, (B) complete rod test display, and (C) broken rod test display.

unity may emerge during the first 4 postnatal months. S. P. Johnson and Náñez (1995) investigated whether this ability might be demonstrated earlier than 4 months of age. Using two-dimensional rod-and-box displays (similar to those used by Kellman & Spelke, 1983, in terms of visual angle and motion of display elements), they replicated the results originally reported by Kellman and Spelke: Four-month-olds consistently looked longer at broken rod test displays than at complete rod displays, after habituation to a rod-and-box display. However, Johnson and Náñez also found that 2-month-olds showed an equal preference for the complete and broken rod after habituation to the rod-and-box display. This lack of a consistent preference indicates that perception of object unity may be emerging at about this time.[1] That is, whereas 4-month-olds prefer the broken rod (and thus infer the unity of the rod pieces) and neonates prefer the complete rod (and thus perceive the rod pieces as disjoint objects), 2-month-olds show a pattern of preferences in between these two types of response.

S. P. Johnson and Náñez (1995) discussed several interpretations of this result in terms of the abilities necessary (but not individually sufficient) for perception of object unity. First, a minimal level of visual resolution is necessary to distinguish the display elements. Second, the visual information relevant to object unity must be noted (e.g., depth placement of display elements, common motion of the rod pieces). Third, it may be that inferential ability, a cognitive skill, also plays a role in perception of object unity.

The first of these interpretations can be ruled out. It seems implausible that limitations in visual resolution could have prevented the 2-month-olds from distinguishing among display elements (see Aslin, 1987), because Slater et al.'s (1990, in press) neonates consistently preferred the complete rod to the broken rod after habituation. However, neither of the other possible explanations can be ruled out at this time. The present study is an investigation of the likelihood that limitations in perception of relevant visual information, or perhaps cognitive skills (i.e., inference), were responsible for the 2-month-olds' response pattern reported by S. P. Johnson and Náñez (1995).

The displays used in the present study were similar to those used by S. P. Johnson and Náñez (1995), except more of the hidden rod's surface was visible behind the occluding box. In the display used by Johnson and Náñez, about 41% of the rod was occluded by the box. In the present study, three displays were used in which the proportion of occlusion was decreased. In the first display, the height of the box was reduced, such that only about 26% of the rod was occluded. In the second and third displays, one or two gaps, respectively, were placed in the occluder, such that portions of the rod were visible as it moved across the display.

It was hypothesized that if more of the rod was visible, the visual information specifying unity would be enhanced compared with the displays used by S. P. Johnson and Náñez (1995). If so, then 2-month-olds might be more likely to perceive the hidden connectedness of the rod pieces in the occlusion displays and look longer at the broken rod as opposed to the complete rod test displays.

Method

Sample

Seventy-two infants (34 girls and 38 boys) constituted the final sample (M age = 61 days, range = 51–79 days). An additional 19 infants were observed but not included in the sample because of fussiness (12), sleepiness (5), or low interrater agreement (2; Pearson $r < .80$). From birth announcements in the local newspaper, we recruited the infants by letters and phone. The majority of the infants were from White, middle-class families.

Design

At the beginning of the experimental session, each infant was randomly assigned (by computer) to view one of six possible habituation displays. Half of the infants were assigned to one of three experimental conditions, and half were assigned to one of three control conditions. There were 12 infants in each condition. Each display depicted two rod pieces, above and below a rectangular box. There were three types of box displays: *small, single gap,* and *double gap* (see Figure 2). For infants in the three experimental conditions, the top and bottom portions of the rod underwent concurrent lateral translation behind the box. For infants in the three control conditions, the bottom portion of the rod remained stationary, and only the top portion of the rod moved laterally. We included the control groups to investigate a possible inherent preference for either of the two test displays.[2] Infants in all six conditions viewed the same two test displays after habituation, consisting of a broken and complete rod in alternation, for three trials each, with counterbalancing of the initial test display.

Apparatus and Stimuli

An Amiga 3000 computer and an 80-cm Sony color monitor were used to generate the displays. Two observers viewed the infant through small peepholes cut into either side of a black panel that extended 47 cm from the monitor.

The computer presented the stimulus displays, stored each infant's

[1] An analysis of individual participant data did not reveal any discernible pattern based on gestational age, habituation time, or sex, which have been thought to be related to maturity in young infants.

[2] It might be argued that infants would perceive this kind of control display as containing two rod parts and thus be biased toward dishabituating to a complete rod test display. Although it is currently unknown how such control display elements are perceived by young infants, infants habituated to this kind of display have shown no consistent preference for either the broken rod or the complete rod (S. P. Johnson & Aslin, 1995; S. P. Johnson & Náñez, 1995; Kellman & Spelke, 1983). Thus the efficacy of this display in assessing posthabituation preferences for the test displays has strong empirical support.

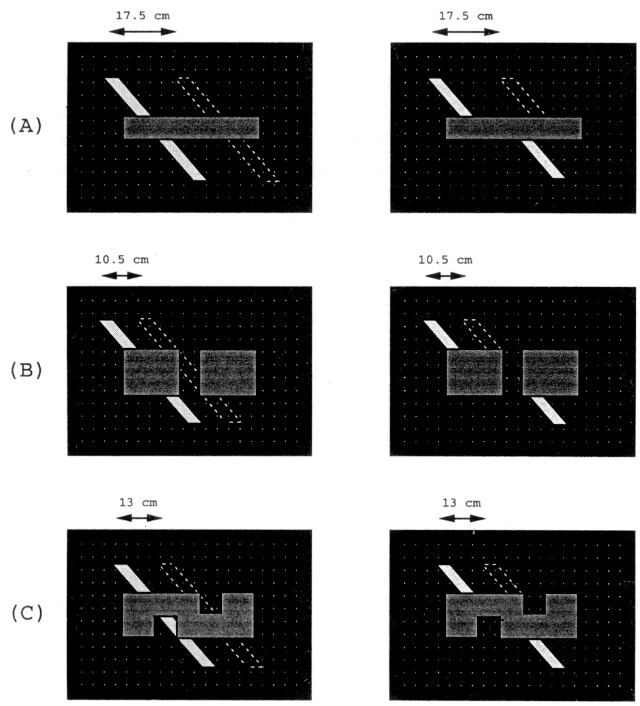

Figure 2. Displays used in the present study: (A) small-box displays, (B) single-gap box displays, and (C) double-gap box displays. Displays for the experimental conditions are shown on the left; displays for the control conditions are shown on the right. The extreme leftmost position of the rod in each display is shown as a solid figure, and the extreme rightmost position as a dotted figure. Note that in the single-gap and double-gap control displays (B and C), the rod was not seen in the gap. See text for details.

data, calculated the habituation criterion for each infant, and changed displays after the criterion was met. The computer also recorded how long the infant looked at each display, according to the observers' judgments. These judgments were entered by way of two handheld microswitches that were connected to the computer's mouse port.

Both observers were unaware of the experimental or control condition of any individual infant and to the stimulus on the screen at any given time. The second observer had never been allowed to view the displays and was naive to the hypotheses under investigation and the experimental design.

The small-box display consisted of a computer-generated 33 × 6.4 cm blue box, subtending 15° × 2.9° visual angle (at the infants' 125-cm viewing distance). The box was oriented with its long axis horizontal. The height of this box was one half of that used by S. P. Johnson and Náñez (1995). The single-gap box measured 33 × 12.7 cm (15° × 5.8°) and contained a 4.4-cm (2°) wide vertical gap in its center, extending from the top of the box to the bottom. The rod was partially visible in the gap for a short time as it translated behind the box; at no time was the rod fully visible. The double-gap box also measured 33 × 12.7 cm and contained two gaps, both measuring 5 × 6.4 cm (2.3° × 2.9°). One gap was 5.7 cm (2.6°) from the top right corner of the box, and the other gap was 5.7 cm from the bottom left corner. The rod was partially visible in each gap in turn as it translated behind the box, but it was never fully visible (see Figure 2).

A yellow rod, 33 cm in length (15°) and oriented 42° counterclockwise from the vertical, underwent lateral translation at a rate of 10.5 cm/s (4.8°/s) behind each box. The rod translated through 17.5 cm (8°) in the small-box condition, 10.5 cm (4.8°) in the single-gap condition, and 13 cm (5.9°) in the double-gap condition. In the control conditions, only the top visible portion of the rod moved, and the bottom remained stationary. In each of the three control displays, the top part of the rod moved at the same rate and distance as in respective experimental displays. In the single-gap and double-gap control displays, the stationary portion of the rod was offset slightly to the right of the box's midpoint so that it was not visible in the gap. The background consisted of a 20 × 12 grid of regularly spaced white dots (texture elements) against a black field. Background texture was deleted at the leading edge of the rod and accreted at the trailing edge of the rod as the rod moved across the screen.

The two test stimuli (broken and complete rods) were similar to the rod portion of the habituation stimuli but were presented without the box. The broken rod contained a 12.7-cm (5.8°) gap in its center (in the small-box condition, this gap was 6.4 cm, or 2.9°), with background texture visible in the gap. The inner edges of the broken rod were always horizontal. Both complete and broken rods moved in the same translatory motion as the rod in the habituation displays.

Procedure

The infants were placed in an infant seat approximately 125 cm from the display monitor, reclined to 30° from vertical. The rod-and-box display was presented until each infant met the habituation criterion. This criterion was defined according to a common infant-control procedure (Horowitz, Paden, Bhana, & Self, 1972) as a decline in looking times during three consecutive trials, adding up to less than half the total looking times during the first three trials. If the total of the looking times during the first three trials was less than 12 s, the criterion was based on the first three subsequent trials for which looking time totaled 12 s or more. (This habituation criterion was the same as in the original study of Kellman & Spelke, 1983, and was also adopted by S. P. Johnson & Náñez, 1995.) The habituation period was terminated if an infant had not met the criterion after 15 trials (n = 4) or if 15 min of total looking time had accumulated (n = 5). The test period followed as with the other infants.

Timing of each trial began when the infant fixated the screen after display onset. Each observer independently indicated how long the infant looked at the display by pressing a separate microswitch as long as the infant fixated the screen and releasing when the infant looked away. An individual trial was terminated when both observers released their microswitches for 2 overlapping seconds (termination of trials was contingent on agreement between observers, as opposed to a single observer, for added reliability). At this point, the screen was turned off by the computer, and the next display appeared 2 s later.

When looking times to the habituation display declined to criterion, the computer changed from habituation to test displays. The two test displays were seen three times each, in alternation, for a total of six posthabituation trials. Half of the infants in each condition viewed the broken rod first after habituation, and half viewed the complete rod first.

Eight infants (3 in the experimental conditions and 5 in the control conditions) viewed only one or two presentations of the three broken or complete rod test displays (because of fussiness) after habituation. For these infants, the missing scores were replaced with the mean of the other scores, for that particular cell, in the analyses of looking times (see later).[3]

[3] The omnibus analysis was repeated without replacement of missing scores. There were no interpretive differences in the outcomes of these two analyses, except for the presence of a significant Condition × Order interaction, $F(1, 46) = 4.30$, $p = .044$, in the analysis without replacement. Infants in the control groups who viewed the broken rod first looked longer overall at both test displays (M = 25.71 s, SD = 28.71) than did infants who viewed the complete rod first (M = 12.33 s, SD =

Results

Each infant contributed six posthabituation looking times to the analyses, three for the broken rod and three for the complete rod. We calculated looking times by averaging the two observers' judgments for each test trial. Interobserver agreement was high for the infants included in the analyses (Pearson correlations averaged .98, range = .91 to .99).

There were occasional looking times that seemed unusually long, perhaps because of difficulty in disengaging attention on the infant's part (so-called *obligatory attention;* see M. H. Johnson, 1990). These extreme scores may not be indicative of interest in the displays. Outliers (scores that exceeded three standard deviations from the mean for their respective cells) were not included in the analyses reported here. There were five outliers, accounting for about 1% of the 432 total observations.[4]

Figure 3 shows the average looking times for infants in the experimental conditions, and Figure 4 shows the average looking times for infants in the control conditions. Figure 5 shows that across the three pairs of test trials, infants in the experimental conditions looked more at the broken rod than at the complete rod test displays, whereas infants in the control conditions looked about equally at the two displays.

This conclusion was supported by analyses of looking times. A 3 (group: small box, single-gap box, or double-gap box) × 2 (condition: experimental vs. control) × 2 (order: broken rod first vs. complete rod first after habituation) × 2 (display: broken rod vs. complete rod) × 3 (trial: first, second, or third pair of test trials) repeated-measures multivariate analysis of variance (MANOVA) was performed on the looking-time data. There was a significant effect of display, $F(1, 56) = 11.67, p < .01$, due to greater looking overall at the broken rod test displays ($M = 22.74, SD = 28.56$) than at the complete rod test displays ($M = 15.24, SD = 17.21$). There was also a significant Condition × Display interaction, $F(1, 56) = 9.96, p < .01$. There were no other significant main effects or interactions.

The Condition × Display interaction resulted from significantly greater looking at the broken rod ($M = 26.71, SD = 32.38$) than at the complete rod ($M = 12.56, SD = 14.60$) by those infants in the three experimental groups, $F(1, 32) = 13.99, p < .01$ (there were no significant differences in dishabituation patterns between the three experimental groups). In contrast, infants in the three control conditions looked about equally at the broken rod ($M = 18.80, SD = 23.70$) and at the complete rod ($M = 17.88, SD = 19.13$), $F(1, 34) = 0.05$, *ns.*

Planned comparisons of looking times to the broken and complete rods were also conducted for each condition, with a series of 2 (display) × 3 (trial) repeated-measures MANOVAs. A test of habituation–dishabituation to the broken versus complete rods was also conducted for each condition (i.e., average looking time to the broken rod displays was compared with the last habituation looking time by means of *t* test; this was repeated for the complete rod displays).

For the small-box experimental condition, there was a significant effect of display, $F(1, 11) = 13.93, p < .01$, resulting from greater looking times to the broken rod than to the complete rod (all 12 infants in this condition preferred the broken rod, as determined by comparing total looking at the broken rod displays to total looking at the complete rod displays). There were no other significant main effects or interactions. In contrast, there were no significant main effects or interactions for the small-box control condition (only 5 of the infants in this condition preferred the broken rod). The infants in the small-box experimental condition reliably dishabituated to the broken rod, $t(11) = 2.41, p < .05$, but not to the complete rod, $t(11) = -1.38$, *ns.* Infants in the small-box control condition did not dishabituate either to the broken rod, $t(10) = 0.97$, *ns,* or to the complete rod, $t(10) = -1.01$, *ns.*

For the single-gap box experimental condition, there was a significant effect of display, $F(1, 11) = 5.11, p < .05$, the result of greater looking times to the broken rod than to the complete rod (8 of the infants in this condition preferred the broken rod). There were no other significant main effects or interactions. There were no significant main effects or interactions for the single-gap box control condition (4 of the infants in this group preferred the broken rod). Infants in the single-gap box experimental condition dishabituated to some extent to the broken rod, $t(10) = 1.36, p = .07$ (one-tailed), but continued to habituate to the complete rod, $t(10) = -1.91, p < .05$ (one-tailed). Infants in the single-gap box control condition dishabituated somewhat both to the broken rod, $t(11) = 1.68, p = .06$ (one-tailed), and to the complete rod, $t(11) = 1.81, p < .05$ (one-tailed).

For the double-gap box experimental condition, there was a marginally significant effect of display, $F(1, 11) = 3.78, p = .078$, resulting from greater looking times to the broken rod than to the complete rod (10 of the infants in this condition preferred the broken rod). There was also a significant effect of trial, $F(2, 22)$, $= 3.71, p < .05$, resulting from a decline in interest across test trials. There were no significant main effects or interactions for the double-gap box control condition (5 of the infants in this condition preferred the broken rod). Infants in the double-gap box experimental condition dishabituated moderately to the broken rod, $t(11) = 1.58, p = .07$ (one-tailed) but not to the complete rod, $t(11) = 0.32$, *ns.* Infants in the double-gap box control condition did not dishabituate either to the broken rod, $t(11) = 0.57$, *ns,* or to the complete rod, $t(11) = 0.46$, *ns.*

In summary, the overall pattern of results indicates that the infants in the experimental conditions preferred the broken rod over the complete rod, after habituation to a rod-and-box display. Infants in the control conditions seemed to prefer neither the broken rod nor the complete rod. This suggests that the infants who viewed displays in which both rod pieces moved con-

13.97). Infants in the experimental conditions looked about equally at the test displays, regardless of order (for broken rod first, $M = 18.06$ s, $SD = 30.38$; for complete rod first, $M = 20.25$ s, $SD = 20.00$). It is unclear why this occurred.

[4] The omnibus analysis was repeated including outliers. There were no interpretive differences in the outcomes of the two analyses, except for an effect of group, $F(2, 60) = 3.18, p = .049$, and a Group × Order interaction, $F(2, 60) = 3.24, p = .046$, in the analysis inclusive of outliers. These effects were due to the presence of one outlier in the single-gap, broken rod first condition, and three outliers in the double-gap, broken rod first condition.

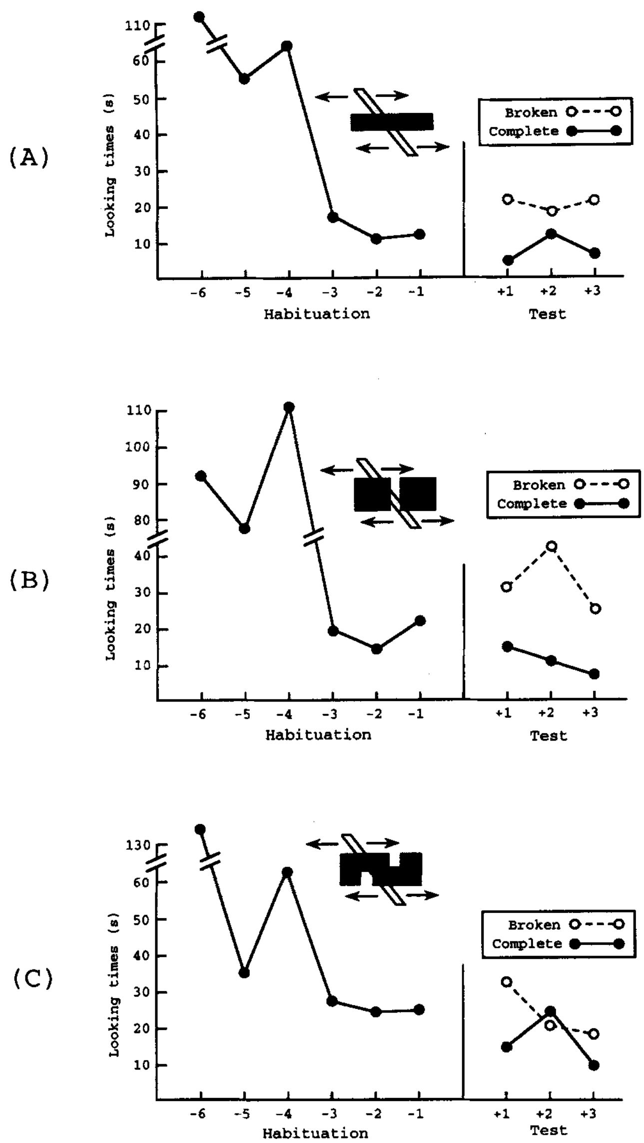

Figure 3. Mean looking times by infants in (A) the small-box experimental condition, (B) the single-gap box experimental condition, and (C) the double-gap box experimental condition.

currently behind the box represented the occluded connectedness of the rod. Strongest support for this claim is found in the small-box condition.

Discussion

The present study has demonstrated that infants as young as 2 months of age seem to perceive object unity in some partial occlusion displays. In contrast, S. P. Johnson and Náñez (1995) found that 2-month-olds apparently do not perceive object unity in two-dimensional displays similar to those used in the present study, except for the dimensions of the occluding box. Even when three-dimensional displays are used, 2-month-olds do not necessarily perceive the unity of the rod behind the box (S. P. Johnson, Slater, & Aslin, 1994). Neonates also do not seem to perceive object unity in three-dimensional displays (Slater et al., 1990), even with a large difference in depth between the rod and box (Slater et al., 1994) and the presence of background texture and reduced occluder size (Slater et al., in press).

Apparent inconsistencies in infants' perception of object unity were also noted by Kellman and Spelke (1983), who found that 4-month-olds do not seem to perceive the unity of two rod pieces that do not move concurrently in relation to a stationary occluder (i.e., when the occluder moves concurrently with the rod, when the occluder moves relative to a stationary rod, or when all display elements are stationary). Moreover, 4-month-olds do not seem to perceive object unity in two-dimen-

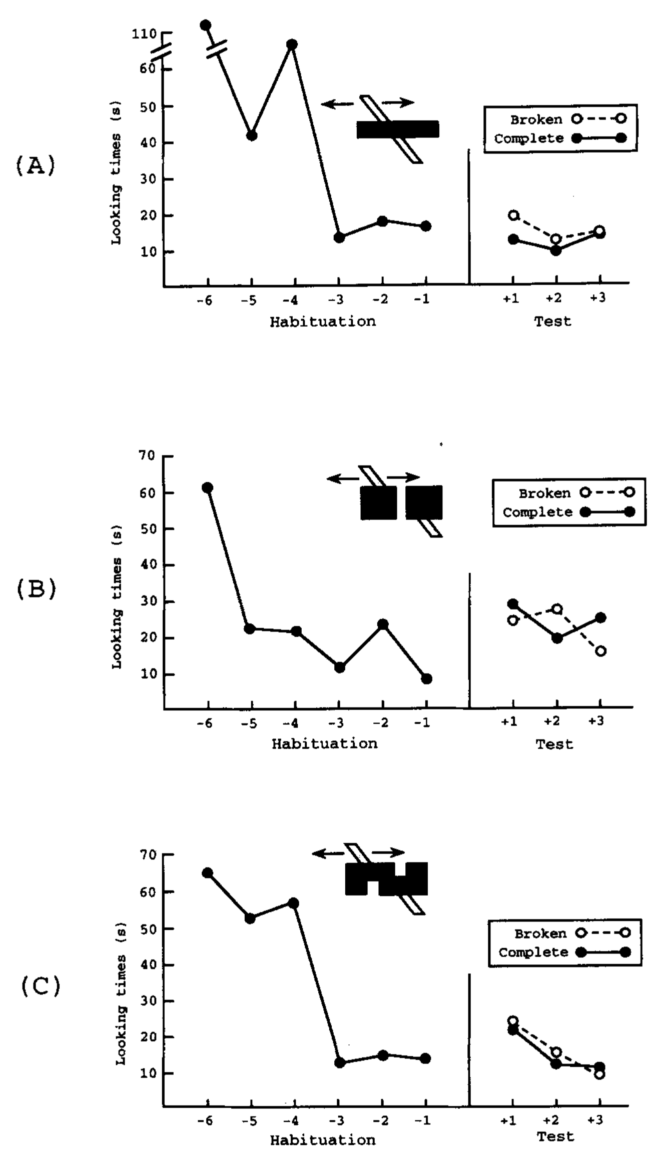

Figure 4. Mean looking times by infants in (A) the small-box control condition, (B) the single-gap box control condition, and (C) the double-gap box control condition.

sional displays in the absence of background texture or when the rod pieces are misaligned (S. P. Johnson & Aslin, 1995). Thus, even for older infants who show clear evidence of perception of object unity under many stimulus conditions, there are other conditions that do not support object unity.

There were several kinds of visual information in the rod-and-box displays used in the present study that potentially could support perception of object unity. These included the common motion and alignment of the rod pieces above and below the box, as well as depth cues (e.g., interposition of rod pieces behind the box and accretion and deletion of background texture by the moving rod) specifying the apparent spatial separation of the rod, box, and background.

Precisely which information was attended to and which is the *sine qua non* of young infants' perception of object unity are not known at this time. However, it seems reasonable to conclude that the 2-month-olds attended to the common motion of the rod pieces, in that perception of object unity is attenuated in older infants when common motion of the rod pieces, in relation to the occluder, is absent (Kellman & Spelke, 1983). Aslin and Shea (1990) found velocity thresholds for slow-moving stimuli of 9°/s for 1.5-month-olds and 4°/s for 3-month-olds. However, the present study suggests that 2-month-olds are sensitive to velocities as low as 4.8°/s (the velocity of the rod pieces behind the box). This is consistent with the results of von Hofsten, Kellman, and Putaansuu (1992) showing a high degree of sensitivity in young infants to coherent motion in motion parallax displays.

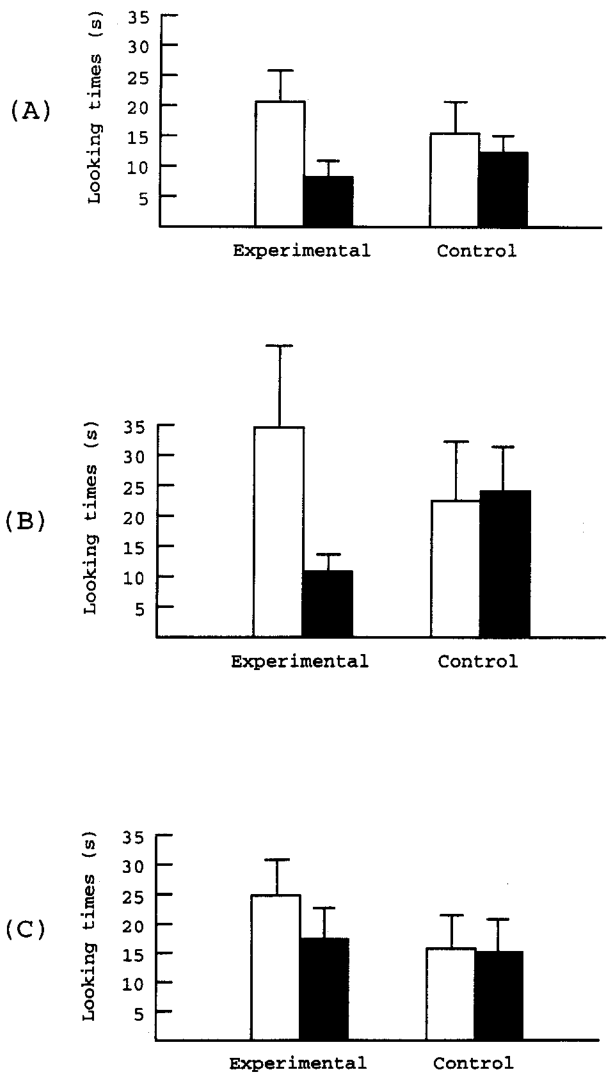

Figure 5. Mean looking times across the three test trials to the broken rod (white bars) and the complete rod (black bars): (A) small-box conditions, (B) single-gap box conditions, and (C) double-gap box conditions. (*Error bars indicate standard error of the mean.*)

It also seems reasonable to conclude that the 2-month-old infants in the present study perceived the depth relations of the display elements veridically and segregated the display into its constituent elements (box, rod, and background). It is unknown at this time if the infants in the present study used only kinetic depth cues (based on motion-carried information) or if supplementary information from other depth cues was also used in perception of depth placement (see S. P. Johnson & Aslin, 1995). This finding may necessitate a reconsideration of the commonly held view that not until after 5 months of age do infants perceive depth from so-called "pictorial" depth cues, such as interposition (Yonas & Granrud, 1985).

Another aspect of the present results involves temporal integration. The single-gap and double-gap conditions, in addition to coherent motion of the two rod pieces, provided the infants with information about the existence of the hidden portion of the rod as it was revealed over time. In the single-gap condition, adjacent portions of the rod were revealed with little delay, and in the double-gap condition, there was a delay of approximately 2 s. Previous research on infants' integration of information over time has demonstrated that not until 12 months of age do infants perceive object length through aperture viewing (Arterberry, 1993) and object shape through point-light tracing (Rose, 1988). Van de Walle and Spelke's (1993) study found that 5-month-olds seem to perceive the unity of partly occluded objects when information for connectedness is only available over time. Although we cannot be certain that temporal integration of the existence of the complete rod was essential to the infants' performance in the single-gap and double-gap conditions, this source of information was present, and further investigation of its role in object identity is warranted.

The finding of early perception of object unity is consistent with recent theories suggesting that from an early age, infants experience a world of three-dimensional objects that are coherent, bounded, and separate from the background (e.g., Baillargeon, 1993; Spelke, 1985, 1988). However, neonates do not seem to express an appreciation of the hidden unity of the rod, even when presented with rich, full-cue displays (Slater et al., in press). Thus, a strictly nativist position is not supported by this finding.

How, then, does perception of object unity emerge in infants? It may be that very young infants do not attend to visual information in the same way as do older infants and adults (e.g., attending to coherent motion of disparate display elements). That is, perceptual learning over the first few months of life underlies the very rapid emergence of sensitivity to the hidden portions of objects. This position is supported by the fact that, compared with 4-month-olds, 2-month-olds need extra information to express perception of object unity.

On the other hand, perhaps the capacity to perceive object unity is not expressed in early infancy because of maturational changes that support perception of certain object properties. Recent accounts of early brain development seem useful in this context. M. H. Johnson (1990) speculated that the rapid maturation of the outer layers of cortex following the second month of life may be associated with the emerging functioning of various neuroanatomical pathways. The changes in visual behavior documented in young infants might in some cases depend on these processes. Among these pathways is the temporal lobe pathway, whose functioning seems to be related to identification of objects (Mishkin & Appenzeller, 1987). In the absence of interconnectivity between the temporal lobe and other areas (e.g., V2, V3, and the frontal eye fields), the ability to identify various object properties (such as object unity under conditions of partial occlusion) may not be possible. At the least, these maturing pathways seem central to efficient allocation of attentional resources in very young infants (M. H. Johnson, Posner, & Rothbart, 1991).

Alternatively, it may be that the capacity to perceive object unity develops over the first 2 months of life, because certain concepts (such as object unity) are formed by a mechanism such as that proposed by Mandler (1992). In her view, conceptual structure is derived from perceptual activity through a process of *perceptual analysis.* The earliest concepts are likely to be the most accessible and simple and may be based on image schemas (Lakoff, 1987) that are grounded in the experience of primitive spatial structures. One of these is the LINK image schema, characterized simply as a connection between two entities. Information for this connection may be given by common motion or other kinds of visual information.

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