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BRIEF REPORT

Newborn Infant's Perception of Partly Occluded Objects

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Newborn infants were familiarized to a display which contained multiple cues that specified the completeness or coherence of a partly concealed object. However, the findings from test trials suggested that object unity had not been perceived. Possible reasons for the newborn's limitations, and of age changes in perception of object unity, are discussed.

newborn perception occluded objects object unity

A major focus of research into object perception has been infants' understanding of partly occluded and hidden objects. Although adults have no difficulty in appreciating the coherence of partly occluded objects, and the continued existence of completely occluded objects, Piaget (1952, 1954) argued that these perceptual abilities develop only gradually over infancy, after extensive experience of observing and manipulating objects. The main evidence that Piaget used in drawing this conclusion was infants' failure to reach or search manually for fully or partially hidden objects. However, researchers who have used indices that do not depend on manual activity have provided strong evidence that Piaget underestimated the conceptual abilities of young infants. Kellman and his colleagues (Kellman & Spelke, 1983; Kellman, Spelke, & Short, 1986) investigated infants' perception of partly occluded objects using habituation–dishabituation procedure. Four-month-old infants were habituated to a stimulus (usually a rod) which moved back and forth behind a central occluder, so that only the top and bottom of the rod were visible. On subsequent test displays, the infants were shown two stimuli without the occluder, one being a complete rod, the other being the top and bottom parts of the rod, with a gap where the occluder had been. On these test trials, the infants dishabituated to the rod pieces, but not to the complete rod, suggesting that they had seen the rod as being connected or complete behind the occluder and that the rod pieces were, therefore, novel.

This finding of object unity in 4-month-olds is consistent with the view that "perception of objects may depend on an inherent conception of what an object is" (Kellman & Spelke, 1983, p. 483), and Spelke (1985) put forward the view that infants begin life with an innate conception of the underlying unity, persistence, and coherence of objects. This suggestion has an interesting cross-species parallel. Regolin and Vallortigara (in press) imprinted newborn domestic chicks (*Gallus gallus*) to partially occluded triangles, and on subsequent test trials on Day 3, the chicks consistently chose to associate with a complete triangle rather than a fragmented one. This, together with their other findings, presents a strong case that the chicks were experiencing object completion.

Slater, Morison, et al. (1990) repeated Kellman and Spelke's (1983) basic experiment with human newborn infants and discovered that they do not act like 4-month-olds or like newly hatched chicks. For the newborns, the *continuous* rod was the novel stimulus, a finding which suggests that perhaps infants' understanding of objects changes in the early months

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from birth, and that at birth, perception is dominated by that which is visible, not by that which can be inferred.

However, there are alternative interpretations of the age differences. One possibility is that it is necessary for very young infants to appreciate that the occluded rod is in a different depth plane (behind) than the occluder, and that Slater, Morison, et al.'s (1990) newborn infants did not detect this depth relationship. In their experiments, this gap was about 4 mm, and given the poor visual acuity of newborn infants, it is possible that they saw the rod as moving in the same plane as the occluder, rather than behind it. It would then be quite reasonable for the newborns to perceive the continuous rod as novel on the test trials: This would not imply an inability to "fill in" the occluded portion of the rod, because there would literally be nothing to fill in! This possibility was investigated by Slater, Johnson, Kellman, and Spelke (1994) who tested newborn infants in a condition where the gap between occluder and rod was large enough to be reasonably confident that they detected the separation. In this experiment, the occluder was 15 cm in front of the rod, and in other experiments, newborns have shown reliable changes in preferential looking in response to smaller changes of stimulus distance (Slater, Mattock, & Brown, 1990). However, in Slater et al.'s (1994) study, a reliable preference on the test trials for the *continuous* rod was found, which is a preference in the same direction as that found earlier by Slater, Morison, et al. (1990).

This finding suggests that detection of the three-dimensional depth relationship between object and occluder may not be critical to perception of the completeness (or incompleteness) of a partly occluded object, and it appears to confirm the view that perception of object unity is not innately specified in humans but develops over the first 4 months from birth. However, although it is clear that *some* development takes place over the first few months, it is not clear exactly *what* develops. For example, it could be, as Slater et al. (1990, p. 33) argued, that newborn infants "perceive only that which is immediately visible, and they seem to be unable to make perceptual inferences from visual input." Alternatively, it may be that perception of object unity is innately available to newborns, but that the test displays that have been presented to them in the studies so far reported do not contain sufficient information or cues for this ability to manifest itself.

An indication that the latter might be the case emerged from findings from 2-month-olds reported by Johnson and Náñez (1995) and Johnson and Aslin (1995). In their studies, the infants were tested with two-dimensional computer-generated displays, and Johnson and Nanez found that their subjects showed an equal preference for the complete and broken rods after habituation to the rod-and-occluder display. This might indicate that the infants were uncertain as to whether the rod continued "behind" the occluder or not, and perhaps that perception of object unity is emerging at this time. However, when Johnson and Aslin tested 2-month-olds in conditions where the height of the occluding box was reduced, they found clear evidence of perception of object unity: On the test trials, the infants showed a strong and significant preference for the rod pieces. In these studies, the two-dimensional depth cue of accretion and deletion of surface texture (by the moving rod) was available to the infants, and it is possible that this cue increases the likelihood of perception of object unity.

Thus, in the absence of three-dimensional depth cues, but with "enhanced" displays, infants as young as 2 months perceive object unity, leaving open the possibility that enhanced displays might provide the visual information to support object unity in even younger infants. This report presents data bearing on this possibility. Newborn infants were tested with an enhanced habituation display which contained two cues that have not previously been present in studies with newborns: These are reduced occluder height and the kinematic cue of accretion and deletion of texture.

Sixteen apparently healthy infants, 8 boys and 8 girls, between the ages of 9.5 and 125.0 hours were the subjects (M = 42.0 hours, SD = 30.2), and throughout testing they remained in the behavioral state of alert inactivity (Ashton, 1973). Twenty-two additional infants participated in the experiment but could not be used because of falling asleep, crying, or fussing.

An infant-controlled habituation procedure was used (Horowitz, Paden, Bhana, & Self, 1972). Each newborn subject was tested while seated upright on an experimenter's knee, with his/her eyes 40 cm from the center of a matte-

white stimulus screen painted with evenly spaced black dots, each 5 mm in diameter and separated center to center by 1.5 cm. During habituation trials, a dark red rod, 18 cm high and 2 cm wide, angled 20° from the vertical, moved back and forth behind a central light-green occluder (2.4 cm high and 10.0 cm wide). In the newborn studies of Slater et al. (1990, 1994), the height of the occluder was 4.4 cm, and in this study, it was therefore reduced in height by 2.0 cm. One complete cycle of movement of the rod took 4 s, and the rod moved 2.5 cm to each side of the center point, deleting and accreting the textured background during its movement. The occluder was 23 cm from the infant's eyes, and the front surface of the moving rod was 38 cm. An infant being shown the habituation display is presented in Figure 1.

The criterion of habituation was a decline in looking to at least 50% of the accumulated looking time on the first three trials. On the test trials following criterion, two paired stimuli were shown, the continuous rod and two rod pieces (the latter separated by a central vertical gap of 2.4 cm), both undergoing the same speed and type of movement as shown on the habituation trials. The left/right order of presentation of the two stimuli on Trial 1 was counterbalanced across subjects and changed from Trial 1 to Trial 2. Visual preference studies by Slater et al. (1990) indicate that there is no "natural," or unlearned, preference for either of these stimuli. Other details of testing are the same as those described in Slater et al. (1994, 1990).

The mean total looking time to reach the criterion of habituation was 125.2 s (SD = 54.7), a time that is comparable to the habituation trials reported by Slater et al. On the test trials following habituation, there was a significant preference for the *continuous*, or complete, rod: 13 of the 16 subjects looked more at this stimulus, which attracted 66.2% (SD = 14.9) of the looking time, $t(15) = 4.34$, $p < .001$. Thus, the newborn infants in this study gave the same novelty response as those in Slater et al. (1994, 1990).

In this study, there seemed to be present all of the cues that could specify depth relationships between the occluder, the rod, and the background, as well as those that could specify object unity. The multiple cues were: the clear depth separation between occluder and rod, and their differing color and brightness, to specify two objects; the narrow occluder whose angular

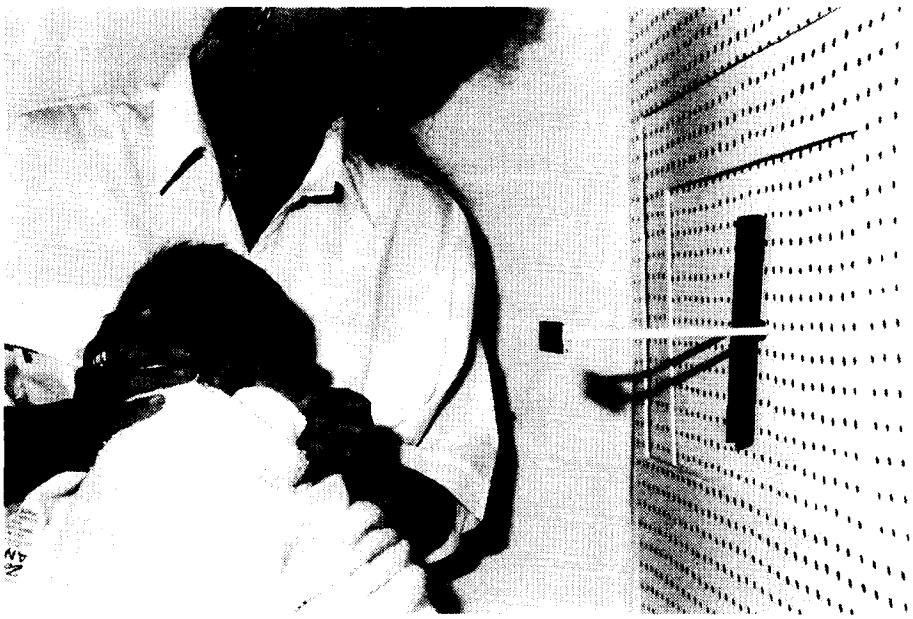

Figure 1. A newborn infant being tested in the habituation phase of the experiment.

height was less than that which specified object unity to Johnson and Aslin's (1995) 2-month-olds; the accretion/deletion of the background texture by the moving rod; the common motion of the rod pieces.

There are several possible accounts of newborn infants' limitations. Spelke (1985, reviewer's comments), following the logic of Johnson and Aslin (1995), argued that it is "not implausible to suggest that as infants grow, they become able to perceive object unity over increasingly large areas of occlusion, and that an occluder size that 2-month-olds can cope with is too big for newborn infants." This possibility, although plausible, is difficult to test because reducing the occluder size even further would limit its detectability for newborns. Another possibility is that sensitivity to kinematic information such as the detection of common motion develops in the 1st month or so, and that this maturational change allows for an innate perception of object unity to emerge. Alternatively, it may be that experience viewing objects and events is necessary for the development of an understanding of object properties. Because, as mentioned earlier, newly hatched chicks display object unity, it seems that at least some precocial species have a different visual start to life than those of at least one altricial species. What this experiment has clearly shown is that it seems unlikely that newborn infants have the ability to appreciate or perceive that a partly occluded object is coherent or complete behind the occluder, and it is certainly the case that this appreciation shows considerable development in the first 4 months of life.

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