EFFECTS OF PRIOR EXPERIENCE ON 4.5-MONTH-OLD INFANTS' OBJECT SEGREGATION

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Adults bring to bear at least three types of object knowledge—configural, experiential, and physical knowledge—when segregating displays. Prior research suggests that young infants lack configural knowledge: they do not expect similar surfaces to belong to the same units and dissimilar surfaces to distinct units. The present research asked whether young infants could make use of another type of object knowledge, experiential knowledge, when organizing displays. In the first experiment, 4.5-month-old infants were familiarized with a stationary display composed of a yellow cylinder lying next to a tall, blue box. In the test events, a gloved hand grasped the cylinder and pulled it a short distance to the side; the box either moved with the cylinder (move-together condition) or remained stationary (move-apart condition). The infants tended to look equally at the move-apart and the move-together events, as though they were uncertain whether the cylinder and box constituted one or two units. Subsequent experiments examined whether infants would respond differently to the cylinder-and-box display if they were briefly exposed to the box alone (Experiment 2), or to the cylinder alone (Experiments 3 and 4), prior to seeing the test events. The results indicated that the infants' responses to the cylinder-and-box display were affected by these prior experiences: after seeing the box alone for 5 s, or the cylinder alone for 15 s, the infants looked reliably longer at the move-together than at the move-apart event, suggesting that they now viewed the cylinder and box as separate units and hence were surprised in the move-together event when they moved as one. In a final experiment (Experiment 5), infants were found to be able to use a prior experience with the box to parse the cylinder-and-box display even if this experience took place in a different setting (the infants' homes) and as long as 24 hours before the infants were shown the test events in the laboratory. Together, the present findings provide strong evidence that 4.5-month-old infants, like adults, use their experiential knowledge when segregating displays.

object perception prior knowledge memory

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INTRODUCTION

Consider a typical office in the aftermath of the preparation of a grant proposal, with papers, books, calculators, pens, diskettes, staplers, and cups stacked untidily upon every available surface. When contemplating (dejectedly) such a scene, we perceive not tangled contours, not confused fragments, but distinct, complete objects. How is the process of object segregation accomplished?

Researchers have long been interested in identifying the various factors that affect adults' carving of three-dimensional scenes into separate objects. One such factor, adults' knowledge about objects, was discussed over a century ago by James (1890). Many investigators have since incorporated this factor into their accounts of how adults (and, in some cases, machines) interpret visual stimuli (e.g., Biederman, 1987; Gregory, 1980; Hummel & Biederman, 1992; Humphreys & Bruce, 1989; Kellman & Spelke, 1983; Marr, 1982; Minsky, 1975; Peterson, 1994; Shepard, 1983; Spelke, 1985a, 1991). Following these investigators' lead, we distinguish between three kinds of object knowledge that adults draw upon when segregating three-dimensional displays: configural, physical, and experiential knowledge.

Configural knowledge refers to adults' expectations about how objects typically appear: adults recognize that objects are generally regular in shape, pattern, color, and texture. As a result, adults tend to group surfaces that present similar configural properties into the same units, and surfaces that present different configural properties into separate units. Thus, using configural knowledge to analyze the cluttered office scene described earlier would lead us to perceive a blue, square diskette and a black, rectangular stapler as distinct objects, because of the marked discontinuities in their appearance.

Physical knowledge corresponds to adults' beliefs about the lawful ways in which objects can move and interact, such as the beliefs that objects cannot remain stable without support or move through space occupied by other objects. To illustrate, the use of physical knowledge would lead us to see the handles of desk drawers as attached to the drawers, because we would understand that the handles could not remain stable if unattached.

Finally, *experiential* knowledge refers to adults' knowledge of what specific objects, or types of objects, exist in the world. This knowledge involves representations of particular objects (e.g., our glasses, key ring, or computer) as well as more abstract representations of object categories (e.g., pencils, chairs, and rulers). The use of experiential knowledge would enable us to see the metallic blade and carved handle of a fanciful letter opener as a single unit, even if the connection between them were hidden from view, because of our prior experiences with such objects.

OBJECT SEGREGATION IN INFANTS

Do infants make use of the same kinds of object knowledge as adults to segregate displays? Over the past 15 years, a large number of experiments conducted by Kellman, Spelke, and their colleagues have examined young infants' use of configural knowledge in organizing stationary three-dimensional displays (e.g., Kellman & Spelke, 1983; Kestenbaum, Termine, & Spelke, 1987; Prather & Spelke, 1982; Schmidt & Spelke, 1984; Schmidt, Spelke, & LaMorte, 1986; Schwartz, 1982; Spelke, Breinlinger, Jacobson, & Phillips, 1993; Termine, Hrynick, Kestenbaum, Gleitman, & Spelke, 1987). These investigations were designed to establish whether young infants, like adults, segregate displays according to their featural properties, grouping together similar but not dissimilar surfaces. The results of the experiments were typically negative and led their authors to conclude that young infants do not possess the same configural expectations as adults.[1]

In light of these negative findings, we decided to explore whether young infants could make use of a different kind of object knowledge, experiential knowledge, to segre-

gate displays that they were unable to organize based on featural information alone. The present research examined whether young infants would be more likely to succeed in parsing a display after being exposed to one of the objects in the display.

There were at least two reasons to expect that young infants might bring to bear a prior experience with an object to segregate a display comprising the object. First, experiments on a number of infant perceptual abilities have found that prior experiences with objects affect infants' perceptions of the same or similar objects (e.g., Bertenthal, 1993; Bushnell, 1986; Granrud, Haake, & Yonas, 1985; Yonas, Pettersen, & Granrud, 1982). For example, Granrud et al. (1985) gave 7-month-old infants a large and a small novel object to play with for a 10-min familiarization phase. During the test phase, the infants were presented with two objects: the large object, and a version of the small object enlarged to be of the same size as the large object. The two objects were positioned at the same distance from the infant, who was allowed to reach for them. Under monocular viewing conditions, the infants reached reliably more toward the previously small object, suggesting that they perceived it to be nearer than the large object. These and control results indicated that the infants used their knowledge of the objects' sizes, acquired during the familiarization phase, to estimate the objects' distances.

The second reason to expect that young infants might take advantage of a prior experience with an object to parse a display containing the object came from a preliminary experiment by Schwartz (1982). This experiment examined 5-month-old infants' perception of partly occluded displays. The infants were shown slides depicting center-occluded, oval-shaped stimuli filled with the features of a face or a checkerboard pattern. The infants who saw the partly occluded face inferred a connection between the visible portions, whereas the infants who saw the partly occluded checkerboard did not. These findings suggested that, by 5 months of age, infants draw on their prior experiences with faces to group together the upper and lower portions of a partly occluded face.

The present research built on these earlier results (e.g., Granrud et al., 1985; Schwartz, 1982) and asked whether 4.5-month-old infants could recruit a brief experience with a novel object to organize a display comprising the object.

The display used in the present experiments was one we had used previously in an experiment on 8-month-old infants' perception of adjacent objects (Needham & Baillargeon, 1997). The infants in this experiment first received a familiarization trial in which they saw an adjacent display consisting of a yellow, zigzag-edged cylinder on the left, and a blue, rectangular box on the right (see Figure 1). The purpose of this familiarization trial was to give the infants the opportunity to inspect the display and form an interpretation of its composition. Next, the infants watched a test event in which a gloved hand took hold of the cylinder and pulled it a short distance to the left. For half of the infants, the cylinder and box moved together as one unit (move-together condition); for the other infants, the cylinder moved apart from the box, which remained stationary (move-apart condition). The rationale was that if the infants viewed the cylinder-and-box display as composed of two units, they would expect the cylinder and box to move independently and be surprised when they did not. On the other hand, if the infants perceived the display as a single unit, they would expect it to move as a whole and be surprised when it did not. Because infants' surprise at an event typically manifests itself by prolonged attention to the event (e.g., Bornstein, 1985; Spelke, 1985b), the infants were expected to look reliably longer at whichever test event depicted the motion inconsistent with their interpretation of the cylinder-and-box display.

The infants looked reliably longer when both the cylinder and box moved than when only the cylinder moved. These and control results indicated that the infants (a) were led

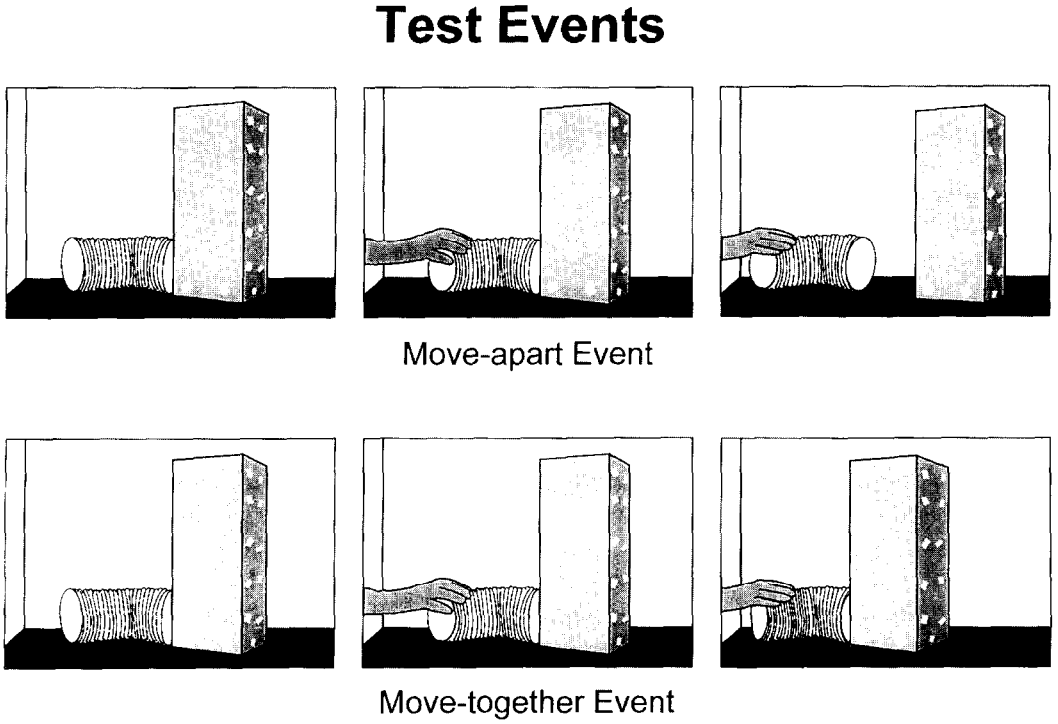

FIGURE 1.
Schematic drawing of the test events seen by the infants in the move-apart and the move-together conditions in each experiment.

by the featural differences between the cylinder and the box to view them as separate units and hence (b) expected the cylinder to move alone when pulled and were surprised that it did not. These findings suggested that, by 8 months of age, infants bring to bear configural knowledge when organizing stationary adjacent displays.

The present research involved five experiments. Experiment 1 examined 4.5-month-old infants' perception of the cylinder-and-box display using a procedure similar to that of our experiment with 8-month-olds (Needham & Baillargeon, 1997). To anticipate, these younger infants did not show a reliable preference for the move-together over the move-apart test event, suggesting that they (a) were uncertain whether the cylinder and box constituted one or two units and hence (b) could not determine whether the cylinder should move with or without the box.

In Experiments 2 to 5, we asked whether 4.5-month-old infants would respond to the cylinder-and-box display differently if they were exposed during the familiarization trial to the box alone (Experiments 2 and 5) or to the cylinder alone (Experiments 3 and 4). We reasoned that if the infants (a) recognized, during the test trials, the object they had seen during the familiarization trial[2] and (b) inferred, based on this information, that the box and cylinder were separate units, then they should expect the cylinder to move alone when pulled and be surprised when it did not; the infants

should, therefore, look reliably longer at the move-together than at the move-apart event.

EXPERIMENT 1

Experiment 1 was designed to investigate 4.5-month-old infants' perception of the cylinder-and-box display. Two groups of infants were tested. The infants in the *familiarization* condition received one familiarization trial in which they saw the entire display, followed by two blocks of three test trials in which they saw either the move-together or the move-apart event. The infants in the *no-familiarization* condition were tested with the same procedure except that they received no familiarization trial. We reasoned that, because the infants in the no-familiarization condition had no opportunity to inspect the cylinder-and-box display and judge its composition, their test responses would provide a baseline for interpreting those of the infants in the familiarization condition.

Method

Participants

Participants were 32 healthy, full-term infants (17 male and 15 female) ranging in age from 4 months, 1 day to 5 months, 5 days (M = 4 months, 18 days). Two additional infants were tested and eliminated; they failed to complete at least three valid test trials, because of procedural error. Half of the infants were randomly assigned to the familiarization condition (M = 4 months, 14 days), and half to the no-familiarization condition (M = 4 months, 22 days). Within each of these conditions, half of the infants saw the move-together event (familiarization, M = 4 months, 15 days; no-familiarization: M = 4 months, 22 days), and half saw the move-apart event (familiarization: M = 4 months, 13 days; no-familiarization: M = 4 months, 22 days). The two familiarization and the two Motion Conditions were thus crossed to form four experimental groups.

The infants' names in this and in the subsequent experiments were obtained from birth announcements in local newspapers. Parents were contacted by letters and follow-up phone calls. They were offered reimbursement for their travel expenses but were not compensated for their participation.

Apparatus

The apparatus consisted of a wooden cubicle 182 cm high, 103 cm wide, and 45 cm deep. The infant faced an opening 40 cm high and 93 cm wide in the front wall of the apparatus. The floor of the apparatus was covered with pale blue cardboard and the back and side walls were covered with brightly lined white contact paper.

At the start of each test event, a zigzag-edged cylinder and a rectangular box stood side by side on the apparatus floor. The cylinder was 22 cm long and 10 cm in diameter. It consisted of a rigid section of clothes dryer vent hose that was stuffed and had its ends curved slightly forward. The left end of the cylinder was covered with cardboard; the right end was covered with a thin metal disc. The entire cylinder was painted bright yellow. The box was 32.5 cm high, 12 cm wide, and 12 cm deep. It was made of thick cardboard and was covered with bright blue contact paper decorated with small white squares. One of the box's corners faced the infants; the cylinder lay on the apparatus floor with its right, metallic end set against the box's left rear wall. To help make clear to the infants that the cylinder and box were adjacent, the front 2.5 cm of the cylinder's right end protruded from the box's left corner. The box stood 17.5 cm from the front edge of the apparatus and 30 cm from the right wall; the cylinder lay 20 cm from the front edge of the apparatus and 33 cm from the left wall. Together, the cylinder and box subtended about 29 degrees (horizontal) and 27 degrees (vertical) of visual angle from the infants' viewpoint.

Inset in the left rear wall of the box (not visible to the infants) was a large magnet. This magnet ensured an even contact between the box and the cylinder (whose right metallic end adhered tightly to the magnet) in their starting positions. The magnet also made it possible for the box to move with the cylinder in the move-together condition. In the move-apart condition, a cardboard cover was placed over the magnet and a heavy weight was inserted in the box; these changes ensured that the box remained stationary when the cylinder was pulled.

In each test event, the cylinder was pulled to the side by an experimenter's right hand; the hand wore a bright silver spandex glove 59 cm long. The hand entered the apparatus through an opening 22 cm high and 18 cm wide in the left wall; this opening was partially hidden by a white muslin curtain.

The infants were tested in a brightly lit room. Four clip-on lights (each with a 40-W light bulb) were attached to the back and side walls of the apparatus to provide additional light. Two wooden frames, each 182 cm high and 71 cm wide and covered with blue cloth, stood at an angle on either side of the apparatus. These frames served to isolate the infants from the experimental room. At the end of each trial, a curtain consisting of a muslin-covered frame 100 cm high and 60 cm wide was lowered in front of the opening in the front wall of the apparatus.

Events

The numbers in parentheses indicate the number of seconds needed to perform the actions described. To help the experimenter adhere to the prescribed script, a metronome beat softly once per second.

At the start of each test event, the experimenter's right hand rested on the apparatus floor about half-way between the cylinder and the opening in the left wall. After a 1-s pause, the hand grasped the cylinder at its center (1 s) and pulled it 14 cm to the left at the approximate rate of 7 cm/s (2 s). The hand paused for 1 s and then pushed the cylinder back to its starting position (2 s). The hand then resumed its initial position on the apparatus floor (1 s). Each event cycle thus lasted about 8 s. Cycles were repeated without stop until the computer signaled that the trial had ended (see below). When this occurred, a second experimenter lowered the curtain in front of the apparatus.

The only difference between the move-together and the move-apart test events had to do with the box: in the move-together event, the box moved with the cylinder, its cardboard bottom sliding smoothly over the apparatus floor; in the move-apart event, the box remained stationary throughout the event.

Procedure

During the experiment, each infant sat on his or her parent's lap in front of the apparatus. The infant's head was approximately 65 cm from the box. The parent was asked not to interact with the infant while the experiment was in progress. The parent was also instructed to close his or her eyes during the test trials.

The infant's looking behavior was monitored by two observers who viewed the infant through peepholes in the cloth-covered frames on either side of the apparatus. The observers were not told and could not determine whether the infants were assigned to the move-together or the move-apart condition.[3] Each observer held a button box connected to a DELL microcomputer and depressed the button when the infant attended to the events. 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. Inter-observer agreement was calculated for each 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 in this experiment and in the next experiments averaged 92% or more per trial per infant. The looking times recorded by the primary

observer were used to determine the end of the trials.

The infants in the familiarization condition first received a familiarization trial. As was mentioned earlier, the purpose of this trial was to give the infants the opportunity to inspect the cylinder-and-box display and arrive at an interpretation of its composition. The experimenter's hand did not enter the apparatus during the trial, so as to not distract the infants. The trial ended when the infants either (a) looked away from the display for 2 consecutive seconds after having looked at it for at least 10 cumulative seconds or (b) looked at the display for 30 cumulative seconds without looking away for 2 consecutive seconds. No reliable difference was found between the looking times during the familiarization trial of the infants in the move-together (M = 15.8, SD = 6.2) and the move-apart (M = 17.1, SD = 8.2) conditions, $F(1, 14) = 0.13$. The infants in the no-familiarization condition received no familiarization trial; the experimental session began directly with the test trials.

During the test trials, the infants in the familiarization and no-familiarization conditions saw the test event appropriate for their Motion Condition, as described above, on two blocks of three test trials. Each test trial ended when the infants (a) looked away from the event for 2 consecutive seconds after having looked at it for at least 8 cumulative seconds (the duration of one event cycle) or (b) looked at the event for 60 cumulative seconds without looking away for 2 consecutive seconds.

One of the 32 infants in the experiment contributed fewer than the full set of six test trials to the analyses; this infant completed only five trials, because of fussiness. All participants (in this experiment as well as in the subsequent experiments) were included in the data analyses, whether or not they had completed all six test trials.

Preliminary analyses revealed no reliable effect of sex on the overall looking times, within each familiarization condition, of the infants in the move-together and the move-apart conditions, F's < 0.16; the data were therefore collapsed in subsequent analyses.

RESULTS

Figure 2 presents the mean looking times on each block of test trials of the infants in the two familiarization and the two Motion Conditions. The infants' looking times were analyzed by means of a 2 × 2 × 2 × 3 mixed-model analysis of variance (ANOVA) with Familiarization Condition (familiarization or no-familiarization) and Motion Condition (move-together or move-apart) as between-participants factors and with Block (first or second) and Trial (trials 1 through 3) as within-participants factors. Because the design was unbalanced, the SAS GLM procedure was used to calculate the ANOVA (SAS, 1986). The main effect of Motion Condition was not significant, $F(1, 28) = 2.63$, $p > .05$, nor was the interaction between Familiarization Condition and Motion Condition, $F(1, 28) = 0.001$. Planned comparisons confirmed that there was no reliable difference between the looking times of the infants in the familiarization condition at the move-together (M = 36.1, SD = 21.1) and move-apart (M = 43.7, SD = 20.7) events, $F(1, 28) = 1.38$, $p > .05$), and between the looking times of the infants in the no-familiarization condition at the move-together (M = 27.6, SD = 19.9) and move-apart (M = 34.6, SD = 20.3) events, $F(1, 28) = 1.17$, $p > .05$). The only significant effect in the analysis was that of Block, $F(1, 139) = 12.90$, $p < .0005$, indicating that the infants looked reliably less as the experiment progressed.

Replication

The results of the familiarization condition indicated that, even though the infants were given the opportunity to inspect the cylinder-and-box display, they were uncertain whether the cylinder and box constituted one or two units and thus tended to look equally at the

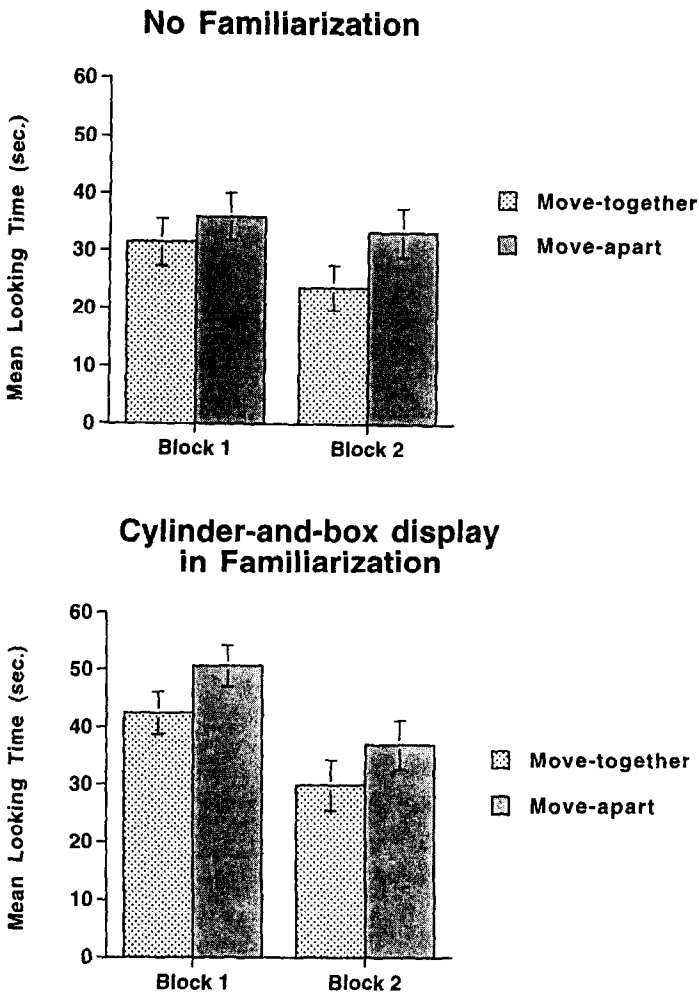

FIGURE 2

Mean looking times of the infants in the familiarization and no-familiarization conditions of Experiment 1. Each graph shows the infants' mean looking at the two test events during the first and second blocks of test trials. The infants in the familiarization condition received a 10- to 30-second familiarization with the adjacent cylinder-and-box display before seeing the test events, whereas the infants in the no-familiarization condition received only the test events.

move-together and move-apart test events. This interpretation was supported by the results of the no-familiarization condition, which showed that no baseline preference for either the move-together or the move-apart event contributed to the infants' test responses.

Because the negative finding obtained with the infants in the familiarization condition provided the basis for our investigation of infants' use of experiential knowledge, it seemed important that it be confirmed. Accordingly, an additional group of 16 infants (8 male and 8 female, range = 4 months, 3 days to 5 months, 6 days, M = 4 months, 15 days) were tested with the same procedure as in the familiarization condition in Experiment

1. Half of the infants were randomly assigned to the move-together condition (M = 4 months, 16 days), and half to the move-apart condition (M = 4 months, 14 days). No reliable difference was found between the looking times during the familiarization trial of the infants in the move-together (M = 18.0, SD = 6.6) and the move-apart (M = 17.9, SD = 7.6) conditions, $F(1, 13) = 0.00$.[4]

One infant failed to contribute six test trials to the analyses; this infant completed only four trials, because of fussiness. Peliminary analyses revealed no reliable effect of sex on the overall looking times of the infants in the move-together and the move-apart conditions, $F(1, 12) = 2.71$, $p > .05$; the data were therefore collapsed in subsequent analyses.

The infants' looking times during the test trials were analyzed by means of a 2 × 2 × 3 ANOVA, with Motion Condition (move-together or move-apart) as a between-participants factor and with Block (first or second) and Trial (trials 1 through 3) as within-participants factors. There was no reliable difference between the looking times of the infants in the move-together (M = 39.9, SD = 18.6) and the move-apart (M = 34.7, SD = 20.7) conditions, $F(1, 14) = 1.20$, $p > .05$. The only significant effect was that of Block, $F(1, 68) = 4.16$, $p < .05$, indicating that the infants looked reliably less as the experiment progressed.

DISCUSSION

When shown the cylinder-and-box display, the 8-month-old infants tested by Needham and Baillargeon (in press) looked reliably longer at the move-together than at the move-apart event, suggesting that they (a) were led by the featural differences between the cylinder and the box to view them as distinct objects and hence (b) expected the cylinder to move alone when pulled and were surprised that it did not. In marked contrast to these older infants, the 4.5-month-old infants in the familiarization condition in Experiment 1 looked about equally at the move-together and move-apart events, suggesting that they (a) were unsure whether the cylinder and box constituted one or two units and as a result (b) were unable to judge whether the cylinder should move with or without the box.

The results of Experiment 1 are consistent with earlier reports that young infants, unlike older infants and adults, do not attend to featural information when organizing stationary three-dimensional displays. The present results differ from previous findings, however, in the specific looking pattern obtained. Spelke and her colleagues (e.g., Kestenbaum et al., 1987; Prather & Spelke, 1982; Spelke et al., 1993) found that 3-month-old infants view adjacent displays as composed of a single unit, regardless of the featural similarities or differences between the surfaces in the displays. The 4.5-month-old infants in the familiarization condition in Experiment 1, in contrast, seemed unable to decide whether the cylinder-and-box display comprised one or two units. The infants' ambiguous percept was in fact similar to the responses observed by Kellman, Spelke, and their colleagues (e.g., Kellman & Spelke, 1983; Prather & Spelke, 1982; Schmidt & Spelke, 1984; Schmidt et al., 1986; Termine et al., 1987) in their investigations of 4- and 5-month-old infants' perceptions of partly occluded displays.

One explanation for the discrepancy between the responses of the 4.5-month-old infants in the present research and of the 3-month-old infants in Spelke's experiments (e.g., Kestenbaum et al., 1987; Prather & Spelke, 1982; Spelke et al., 1993) is that it represents an age difference. As Rochat (e.g., Rochat, 1989; Rochat & Bullinger, in press) and others have reported, important developments take place between 3 and 4 months of age in infants' manipulation of objects, including the beginning of visually-guided exploration and the shift to bringing grasped objects first to the eyes rather than to the mouth. It would not be surprising if, as a result of this increase in visual attention to object features, infants came to revise a primitive belief that adjacent surfaces belong to the same units in

favor of a more realistic expectation that some but not all adjacent displays are composed of a single unit (for further discussion, see Needham & Baillargeon, in press). The finding that 4- to 5-month-old infants' responses to partly occluded displays are typically ambiguous (e.g., Kellman & Spelke, 1983; Prather & Spelke, 1982; Schmidt & Spelke, 1984; Schmidt et al., 1986; Termine et al., 1987) could perhaps be ascribed to a similar development (see Needham & Baillargeon, 1997).

EXPERIMENT 2

The 4.5-month-old infants in the familiarization condition in Experiment 1 had an indeterminate perception of the cylinder-and-box display. Experiment 2 tested whether infants would achieve an unambiguous perception of the display as composed of two distinct units after being exposed to the box alone for 5 s.

The decision to use a brief, 5-s exposure was based on long-standing evidence in the recognition memory literature that, by 5 months of age, infants are capable of recognizing previously experienced stimuli on the basis of very modest amounts of familiarization (e.g., Cornell, 1979; Fagan, 1970, 1971, 1974; Lasky, 1980; Martin, 1975; Rose, 1980, 1981). To illustrate, Fagan (1974) examined how much familiarization time 5-month-old infants required to recognize various stimuli on immediate memory tests. He found that, whereas 20 to 30 s of familiarization time was needed for faces, and 17 s for abstract patterns composed of identical elements, as little as 4 s was necessary for stimuli varying along several dimensions. These results suggested that a 5-s exposure to the box would be sufficient to allow the infants in Experiment 2 to recognize it during the test trials.

Our reasoning was that if the infants (a) recognized the box when presented with the cylinder-and-box display and (b) inferred, based on this information, that the cylinder and box were distinct objects, then they should expect the cylinder to move alone when pulled and be surprised when it did not; the infants should therefore look reliably longer at the move-together than at the move-apart event. Such a positive result, we reasoned, would provide a clear demonstration that 4.5-month-old infants, like adults, use experiential knowledge in organizing stationary three-dimensional displays.

Method

Participants

Participants were 16 healthy, full-term infants (8 male and 8 female) ranging in age from 3 months, 22 days to 4 months, 27 days (M = 4 months, 14 days, SD = 11 days). Two additional infants were tested and eliminated; they failed to complete at least three valid test trials, one because of procedural error and one because of fussiness. Half of the infants were randomly assigned to the move-together condition (M = 4 months, 14 days; SD = 11 days), and half to the move-apart condition (M = 4 months, 15 days, SD = 11 days).

Apparatus, Events, and Procedure

The apparatus, events, and procedure in Experiment 2 were identical to those in the familiarization condition in Experiment 1 with one exception. During the familiarization trial, the infants saw only the box from the cylinder-and-box display. At the start of the trial, the experimenter's gloved right hand rested on the apparatus floor about half-way between the box and the opening in the left wall. After a 1-s pause, the hand grasped the box at its center and lifted it about 11 cm above the apparatus floor (1 s). The hand then tilted the box alternately to the right and to the left, holding each position for 1 s. The infants watched the event until the computer signaled that they had looked at the box for 5 cumulative seconds.

All 16 infants contributed six test trials to the data analyses. Preliminary analyses

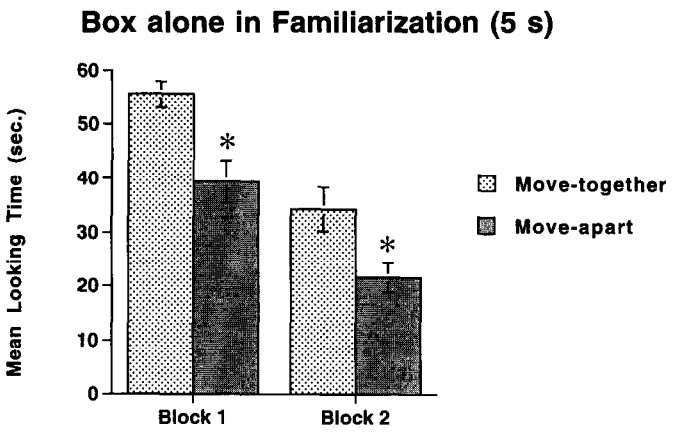

FIGURE 3.
Mean looking times of the infants in Experiment 2 at the two test events during the first and second blocks of test trials. The infants in Experiment 2 received a 5-second exposure to the box alone immediately before seeing the test events.

revealed no reliable effect of sex on the overall looking times of the infants in the move-together and the move-apart conditions, $F(1, 12) = 0.11$; the data were therefore collapsed in subsequent analyses.

RESULTS

Figure 3 presents the mean looking times on each block of test trials of the infants in the two Motion Conditions. It can be seen that the infants in the move-together condition looked longer overall than those in the move-apart condition.

The infants' looking times were analyzed by means of a $2 \times 2 \times 3$ ANOVA, with Motion Condition (move-together or move-apart) as a between-participants factor and with Block (first or second) and Trial (trials 1 through 3) as within-participants factors. The main effect of Motion Condition was significant, $F(1, 14) = 13.65$, $p < .0025$, indicating that the infants in the move-together condition ($M = 44.9$, $SD = 15.9$) looked reliably longer than those in the move-apart condition ($M = 30.4$, $SD = 16.3$).

The ANOVA also yielded significant main effects of Block, $F(1, 70) = 42.10$, $p < .0001$, and Trial, $F(2, 70) = 7.03$, $p < .0025$, indicating that the infants looked reliably less as the experiment progressed.

DISCUSSION

The infants in the familiarization condition in Experiment 1 tended to look equally at the move-together and the move-apart events, as though they were uncertain whether the cylinder and box constituted one or two units. In contrast, the infants in Experiment 2 looked reliably longer at the move-together than at the move-apart event, suggesting that they viewed the cylinder and box as two distinct units and hence expected the cylinder to move alone when pulled and were surprised that it did not.

Together, these results suggest that the familiarization display shown to the infants in Experiment 2 enabled them to arrive at a clear, unambiguous interpretation of the cylinder-and-box display. Recall that the only difference between Experiments 1 and 2 involved the familiarization trial: whereas the infants in the familiarization condition in Experiment 1 saw the entire cylinder-and-box display during the familiarization trial, for 10 to 30 s, the infants in Experiment 2 saw only the box, for 5 s. The results of Experiment 2 make clear

that this brief exposure to the box was sufficient to help the infants determine that the cylinder-and-box display was composed of two units, the box seen during the familiarization trial and an adjacent, separate cylinder. As such, the present results provide evidence that, by 4.5 months of age, infants are able to use prior knowledge of an object to organize an adjacent display containing the object. Such a finding demonstrates that young infants, like adults, bring to bear their experiential knowledge when segregating stationary three-dimensional scenes.

Experiment 3 sought to confirm the results of Experiment 2. The procedure was identical to that of Experiment 2 with one exception: the infants were shown the cylinder instead of the box during the familiarization trial. We wanted to establish whether exposure to the cylinder—a more complex and perhaps less familiar object than the box—would be as successful as exposure to the box in facilitating the infants' segregation of the cylinder-and-box display.

EXPERIMENT 3

Method

Participants

Participants were 16 healthy, full-term infants (8 male and 8 female) ranging in age from 3 months, 22 days to 4 months, 24 days (M = 4 months, 9 days; SD = 10 days). One additional infant was tested and eliminated; this infant failed to complete at least three valid test trials, because of fussiness. Half of the infants were randomly assigned to the move-together condition (M = 4 months, 10 days; SD = 9 days), and half to the move-apart condition (M = 4 months, 9 days; SD = 11 days).

Apparatus, Events, and Procedure

The apparatus, events, and procedure used in Experiment 3 were identical to those in Experiment 2 with one exception: the cylinder was used in place of the box during the familiarization trial. All 16 infants in the experiment contributed six test trials to the data analyses. Preliminary analyses revealed no reliable effect of sex on the overall looking times of the infants in the move-together and the move-apart conditions, $F(1, 12) = 0.33$; the data were therefore collapsed in subsequent analyses.

RESULTS

Figure 4 presents the mean looking times on each block of test trials of the infants in the two Motion Conditions. It can be seen that the infants in the move-together and move-apart conditions tended to look equally at the events they were shown.

The infants' looking times were analyzed as in Experiment 2. The main effect of Motion Condition was not significant, $F(1, 14) = 0.04$, indicating that there was no reliable difference between the looking times of the infants in the move-together (M = 38.8, SD = 17.9) and the move-apart (M = 37.7, SD = 20.5) conditions. The only significant main effects were those of Block, $F(1, 14) = 13.02$, $p < .005$, and Trial, $F(2, 56) = 4.88$, $p < .025$, indicating that the infants looked reliably less as the experiment progressed.

DISCUSSION

After a 5-s exposure to the *box* alone, the infants in Experiment 2 looked reliably longer at the move-together than at the move-apart event, suggesting that they perceived the cylinder-and-box display as composed of two separate units. After a 5-s exposure to the *cylinder* alone, however, the infants in Experiment 3 looked about equally at the two test events, as though they were uncertain whether the cylinder and box constituted one or two units. This ambiguous response was similar to that observed in the familiarization condition in Experiment 1, where the infants were pre-

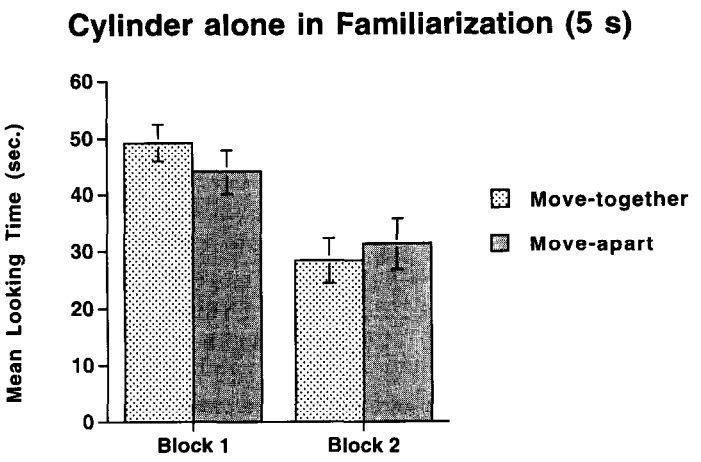

FIGURE 4.
Mean looking times of the infants in Experiment 3 at the two test events during the first and second blocks of test trials. The infants in Experiment 3 received a 5-second exposure to the cylinder alone immediately before seeing the test events.

sented with the entire cylinder-and-box display during the familiarization trial.

How could one explain the discrepancy between the results of Experiments 2 and 3? One possibility was that, because the cylinder was more complex, less regular, and/or perhaps less familiar than the box, a 5-s exposure to the cylinder did not give the infants sufficient time to familiarize themselves with it; as a result, they failed to recognize it when presented with the cylinder-and-box display and hence had no experiential knowledge to bring to bear when segregating the display.

A straightforward prediction of the above analysis was that infants' performance should improve following a longer exposure to the cylinder. Experiment 4 was designed to test this prediction. The experiment was identical to Experiment 3 except that the infants looked at the cylinder for 15 as opposed to 5 cumulative seconds during the familiarization trial. It was hoped that this longer exposure would enable the infants to recognize the cylinder in the test trials and thus affect their interpretation of the cylinder-and-box display.

EXPERIMENT 4

Method

Participants

Participants were 16 healthy, full-term infants (7 male and 9 female) ranging in age from 4 months, 4 days to 4 months, 29 days (M = 4 months, 20 days; SD = 8 days). Seven additional infants were tested and eliminated; they failed to complete at least three valid test trials, three because of procedural error, two because of fussiness, and two because of drowsiness. Half of the infants were randomly assigned to the move-together condition (M = 4 months, 17 days; SD = 10 days), and half to the move-apart condition (M = 4 months, 23 days; SD = 8 days).

Apparatus, Events, and Procedure

The apparatus, events, and procedure in Experiment 4 were identical to those in Experiment 3 except that the familiarization trial

continued until the infants had accumulated 15 s of looking at the cylinder. All 16 infants in the experiment contributed six test trials to the data analyses. Preliminary analyses revealed no reliable effect of sex on the overall looking times of the infants in the move-together and the move-apart conditions, $F(1, 12) = 0.15$; the data were therefore collapsed in subsequent analyses.

RESULTS

Figure 5 presents the mean looking times on each block of test trials of the infants in the two Motion Conditions. It can be seen that the infants in the move-together condition looked longer overall than those in the move-apart condition.

The infants' looking times were analyzed as in Experiment 3. The analysis yielded a significant main effect of Motion Condition, $F(1, 14) = 15.56$, $p < .0025$, indicating that the infants in the move-together condition ($M = 42.8$, $SD = 17.3$) looked reliably longer than those in the move-apart condition ($M = 24.8$, $SD = 16.0$). There was also a significant main effect of Block, $F(1, 70) = 11.43$, $p < .0025$, indicating that the infants looked reliably less as the experiment progressed.

DISCUSSION

After a *5-s* exposure to the cylinder alone, the infants in Experiment 3 tended to look equally at the move-together and move-apart events, as though they were uncertain whether the cylinder-and-box display comprised one or two units. After a *15-s* exposure to the cylinder, however, the infants in Experiment 4 performed very differently: they looked reliably longer at the move-together than at the move-apart event, suggesting that they (a) perceived the cylinder and the box as distinct units and hence (b) expected the cylinder to move alone when pulled and were surprised that it did not.

Together, the results of Experiments 3 and 4 provide evidence that a 15- but not a 5-s exposure enabled the infants to encode sufficient information about the cylinder to recognize it when they next encountered it in the test display. This finding is consistent with a large body of evidence that infants, like chil-

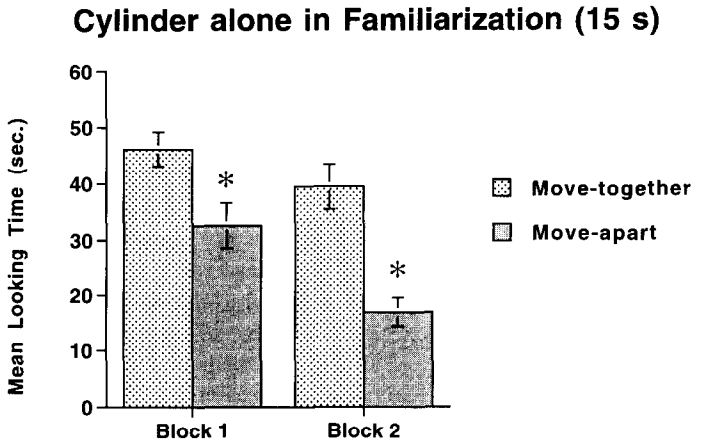

FIGURE 5.
Mean looking times of the infants in Experiment 4 at the two test events during the first and second blocks of test trials. The infants in Experiment 4 received a 15-second exposure to the cylinder alone immediately before seeing the test events.

dren and adults, are often able to recognize with longer exposures stimuli which they fail to recognize following shorter exposures (e.g., Cornell, 1979; Fagan, 1974, 1977; Haith, Morrison, & Sheingold, 1970; Lasky, 1980; Loftus, 1972; Potter & Levy, 1969; Rose, 1980, 1981; Rose & Slater, 1983; Werner & Perlmutter, 1979).

Why was a 5-s familiarization time sufficient for the infants in Experiment 2 to recognize the box, and a longer familiarization time necessary for the infants in Experiment 4 to recognize the cylinder? One possibility, already mentioned earlier, is that this discrepancy stemmed from differences between the objects themselves: the shape of the cylinder was more complex, less regular, and very likely less familiar to the infants than that of the box (infants must often see rectangular objects in their daily environments, but not zigzag-edged, curved cylinders). Another, less likely but nevertheless logical possibility is that the design of the present experiments facilitated the infants' recognition of the box relative to that of the cylinder. In Experiment 2, the infants saw the hand manipulate the box in the familiarization trial and the cylinder in the test trials. In Experiments 3 and 4, in contrast, the hand manipulated the cylinder in both the familiarization and the test trials. It could be that this subtle asymmetry served to enhance the infants' recognition of the box, and that the infants in Experiment 3 would have performed better had the box rather than the cylinder been pulled during the test trials. Further research is needed to decide which, if either of these alternatives is correct.

These ambiguities aside, the main import of the present results is that they indicate that infants as young as 4.5 months of age bring to bear prior experiences with objects when segregating adjacent displays involving the objects. Exposure to the box or to the cylinder alone enabled the infants in Experiments 2 and 4 to view the cylinder-and-box display as composed of two distinct units. This clear-cut interpretation contrasts sharply with the ambiguous percept observed in the familiarization condition in Experiment 1, in which the infants were familiarized with the entire cylinder-and-box display prior to the test trials. Together, the present data provide a strong experimental demonstration that 4.5-month-old infants are able to use their experiential knowledge to determine the composition of otherwise ambiguous displays.

Further Results

The results of Experiments 1 to 4 indicate that infants' perception of the cylinder-and-box-display was affected by a 5-s exposure to the box (Experiment 2) or a 15-s exposure to the cylinder (Experiment 4), but not a 5-s exposure to the cylinder (Experiment 3) or a longer exposure to the entire display (familiarization condition in Experiment 1 and replication experiment). These results were based on a comparison in each experiment of the infants' responses to the move-together and move-apart test events. An alternative approach to the data was to compare the responses to the move-together event of the infants who had received a familarization trial and of the infants who had not (no-familiarization condition in Experiment 1). Such comparisons could establish which of the various familiarization experiences examined in the present research had resulted in elevated looking times at the move-together event, relative to those found in the no-familiarization condition. These analyses revealed that the looking times of the infants in the no-familiarization condition at the move-together event (M = 27.6, SD = 19.9) differed reliably from those of (a) the infants in Experiment 2 who were exposed to the box for 5 s (M = 44.9, SD = 15.9), $F(1, 14) = 9.34$, $p < .01$, and also (b) the infants in Experiment 4 who were exposed to the cylinder for 15 s (M = 42.8, SD = 17.3), $F(1, 14) = 8.33$, $p > .05$. No significant difference was found between the looking times of the infants in the no-familiarization condition and those of (a) the infants in Experiment 1 who were familiarized with the entire cylinder-and-box display (M = 36.1, SD = 21.1),

$F(1, 14) = 1.98$, $p > .05$; (b) the infants in the replication experiment who were also exposed to the entire display ($M = 39.9$, $SD = 18.7$), $F(1, 14) = 4.28$, $p > .05$; and (c) the infants in Experiment 3 who were exposed to the cylinder for 5 s ($M = 38.8$, $SD = 17.9$), $F(1, 14) = 3.72$, $p > .05$. These results provide further support for the conclusion that a 5-s exposure to the box or a 15-s exposure to the cylinder enabled the infants to achieve an unambiguous interpretation of the cylinder-and-box display as composed of two distinct units, an interpretation inconsistent with the joint motion of the cylinder and box in the move-together event.

EXPERIMENT 5

The finding in Experiments 2 and 4 that young infants use their experiential knowledge when segregating a stationary three-dimensional scene indicates that they possess a valuable tool for organizing their daily world. According to the present results, an infant who recognizes a rattle standing next to an unfamiliar cup, shoe, or whistle should be able to determine the boundaries of these novel objects because she already knows the boundaries of the rattle. Through this sort of "perceptual bootstrapping", young infants' experiential knowledge might thus considerably facilitate their organization of scenes containing familiar and novel objects.

Experiment 5 began to explore the conditions under which young infants are able to use their experiential knowledge for segregation purposes. Of particular interest were effects of contextual change and of delay: specifically, could infants make use of a prior experience with an object to segregate an adjacent display containing the object, even if the display were encountered in a different context than the object, and after a delay? To return to our previous example, would an infant be able to use her knowledge of a rattle to segregate it from a novel cup, even if she saw the rattle-cup display in a different setting and at a later time than the rattle alone?

After the infants in Experiments 2, 3, and 4 were familiarized with the box or the cylinder, they were immediately tested with the cylinder-and-box display; there was thus, in these experiments, no change in context and no delay between the familiarization and test trials. Experiment 5 differed from Experiments 2 to 4 in both of these respects: the infants were familiarized with the box in their own homes, on the day before they were scheduled to be tested in the lab. Approximately 24 hours before their appointment, an experimenter visited the infants' homes to show them the box, for 2 min (Fagan (1970, 1971, 1973) found this familiarization time to be sufficient for recognition in 5-month-old infants with delays of 1 to 14 days). Sessions in the lab began directly with the test trials; the infants saw either the move-together or the move-apart test events, as in the preceding experiments.

Our reasoning was as follows. If 4.5-month-old infants could use an experience with an object to segregate a display containing the object *only* when this experience took place in the same context and immediately prior to their seeing the display, then the infants in Experiment 5 should perform like the infants in Experiment 1 and unlike the infants in Experiments 2 and 4: they should tend to look equally at the move-together and move-apart events.

On the other hand, if by 4.5 months of age infants could use an experience with an object to organize a display *even* when this experience occured in a different context and as long as 24 hours prior to their seeing the display, then the infants in Experiment 5 should perform like the infants in Experiments 2 and 4: they should look reliably longer at the move-together than at the move-apart event.

Method

Participants

Participants were 16 healthy, full-term infants (8 male and 8 female) ranging in age from 4 months, 0 day to 4 months, 23 days (M = 4 months, 9 days; SD = 7 days). Half of the

infants were randomly assigned to the move-together condition (M = 4 months, 9 days; SD = 8 days), and half to the move-apart condition (M = 4 months, 10 days; SD = 7 days).

Apparatus, Events, and Procedure

The apparatus, events, and procedure in Experiment 5 were identical to those used in the previous experiments, with one important exception: the familiarization trial took place in the infant's own home, as close as possible to 24 hours before the infant's scheduled appointment at the lab (M = 24 hours, 10 minutes). The experimenter knelt in front of the infant, who sat on a parent's lap, and showed the infant an exact replica of the box used in the cylinder-and-box display. The experimenter moved the box from side to side as necessary to maintain the infant's interest. Although most infants did not reach for the box, brief touching of the box was permitted. The infant was encouraged to look at the box until he or she accumulated 2 min of looking (as measured by a stopwatch); the experimenter then removed the box from the infant's view, thus ending the familiarization trial. For 4 of the 16 infants in the experiment, the same experimenter supervised both their familiarization and test sessions; for the remaining 12 infants, different experimenters supervised the two sessions.

All 16 infants in the experiment contributed six test trials to the data analyses. Preliminary analyses revealed no reliable effect of sex on the overall looking times of the infants in the move-together and the move-apart conditions, $F(1, 12) = 0.61$; the data were therefore collapsed in subsequent analyses.

RESULTS

Figure 6 presents the mean looking times on each block of test trials of the infants in the two Motion Conditions. It can be seen that the infants in the move-together condition looked longer than those in the move-apart condition on the second but not the first block of test trials.

The infants' looking times were analyzed as in Experiment 4. The analysis yielded a significant main effect of Block, $F(1, 70) =$

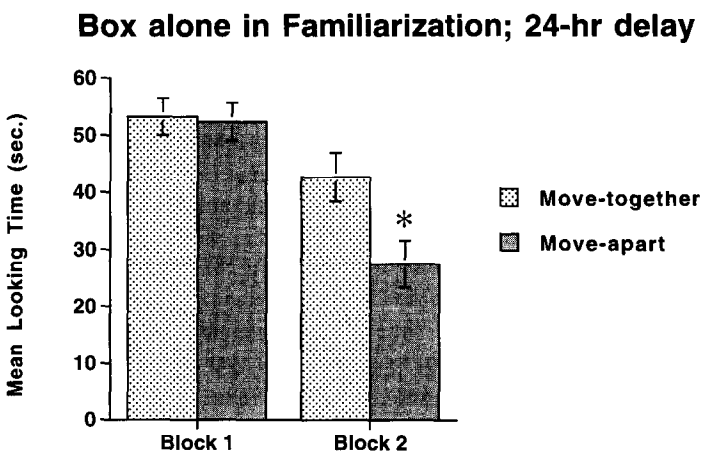

FIGURE 6.
Mean looking times of the infants in Experiment 5 at the two test events during the first and second blocks of test trials. The infants in Experiment 5 received a 2-minute exposure to the box alone in their homes approximately 24 hours before seeing the test events.

30.04, $p < .0001$, and a significant Motion Condition × Block interaction, $F(1, 70) = 4.98$, $p < .05$. Follow-up comparisons confirmed that on the first block of test trials the infants in the move-together ($M = 53.1$, $SD = 15.5$) and the move-apart ($M = 52.3$, $SD = 15.9$) conditions tended to look equally, $F(1, 70) = 0.04$; on the second block of test trials, however, the infants in the move-together condition ($M = 42.7$, $SD = 20.7$) looked reliably longer than those in the move-apart condition ($M = 27.5$, $SD = 20.4$), $F(1, 70) = 11.2$, $p < .0025$. No other effects were significant.

DISCUSSION

The infants in Experiment 5 performed differently in the two blocks of test trials they received. In the first block, the infants looked about equally at the move-together and the move-apart events. In the second block, however, the infants looked reliably longer at the move-together than at the move-apart event. This last result suggests that the infants (a) recognized the box they had seen on the previous day in their homes; (b) used this information to conclude that the cylinder and box were two distinct objects; and hence (c) expected the cylinder to move alone when pulled and were surprised in the move-together event that it did not.

The results of Experiment 5 thus confirm and extend those of Experiments 2 and 4: they provide further evidence that, by 4.5 months of age, infants can bring to bear a prior experience with an object to segregate an adjacent display containing the object. In addition, the present findings begin to shed light on the robustness of this ability: they suggest that, to be of use, infants' experience with an object does not need to occur in the same setting as, or to immediately precede, their encounter with the display. The infants in Experiment 5 were able to use their exposure to the box to parse the cylinder-and-box display, even though they were shown the box in a different context and as long as 24 hours before they saw the display.

Although positive, the results of Experiment 5 were nevertheless weaker than those of Experiments 2 and 4: recall that the infants in these experiments preferred the move-together over the move-apart event in *both* blocks of test trials. Why did the infants in Experiment 5 show a preference for the move-together event only in the second block of trials? One possibility is that, because the infants did not receive their familiarization trial in the apparatus immediately prior to the test trials, they had no opportunity to "orient" themselves to the experiment's apparatus and procedure (e.g., curtain being lifted, gloved hand manipulating an object at the center of the apparatus, and so on). According to this account, the infants would have had to make use of the initial test trials to orient themselves to the experimental situation, thereby compromising their processing of the test events.

This first explanation, though logically possible, does not seem very plausible: it is difficult to imagine what orientation benefits the infants in Experiments 2 and 4 could have derived from their very brief (5 to 15 s) familiarization trials that the infants in Experiment 5 could not have achieved during (even the first portion of) their initial test trial. A second explanation, which we find more compelling, is that the infants in Experiment 5 did not immediately recognize the box upon seeing it again: instead, recognition emerged as the experiment progressed, after two or three test trials (examination of the first block data suggests that by the third test trial the infants were already showing the predicted preference for the move-together event: Trial 1, move-together: $M = 53.3$, $SD = 15.9$, move-apart: $M = 57.3$, $SD = 7.5$; Trial 2: move-together: $M = 54.5$, $SD = 15.6$, move-apart: $M = 54.0$, $SD = 16.6$; Trial 3: move-together: $M = 51.7$, $SD = 17.1$, move-apart: $M = 45.5$, $SD = 20.3$).

Why should the infants have required some exposure to the box to recognize it? Recall that the infants had not seen the box for 24 hours, they were encountering it in an entirely

novel setting, and (particularly for the infants in the move-together condition), they were facing not the box alone (which might have resulted in immediate recognition; e.g., Fagan, 1973) but rather an adjacent display composed of the box and the cylinder. Given all this, it does not seem unlikely that the infants required a few trials to access their stored representation of the box and compare it to that before them.

The explanation just proposed is consistent with findings in the infant memory literature that exposure to a stimulus is sometimes necessary, after a delay, to ensure infants' recognition of the stimulus (e.g., Cornell, 1979; Rovee-Collier & Hayne, 1987; Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980; Sullivan, 1982). One way of testing whether such a "reminding" or "reactivation" process contributed to the block effect in Experiment 5 might be to run the same experiment again with one modification: prior to the test trials, the infants would receive a familiarization trial involving the entire cylinder-and-box display, as in the familiarization condition in Experiment 1. We already know, based on the results of Experiment 1, that such a familiarization trial could not by itself lead the infants to view the cylinder and box as distinct units. Such a trial might, however, give the infants the opportunity to recognize the box. With recognition achieved, one would expect the block effect observed in Experiment 5 to disappear: the infants should show the predicted preference for the move-together event in both blocks of test trials, as in Experiments 2 and 4.

GENERAL DISCUSSION

When shown an adjacent display composed of a yellow cylinder lying next to a tall, blue box, 4.5-month-old infants perceive this display as ambiguous: they are uncertain whether it comprises one or two objects. The present experiments examined infants' ability to use experiential knowledge to disambiguate the display. In Experiment 2, it was found that a 5-s exposure to the box prior to testing allowed infants to view the cylinder-and-box display as composed of two separate units. In Experiments 3 and 4, it was found that a 15-s (but not a 5-s) exposure to the cylinder also enabled infants to see the cylinder and box as distinct objects. In Experiment 5, infants were exposed to the box in their own homes 24 hours before they were tested in the laboratory; even under these conditions, infants were able to parse the cylinder-and-box display into two units.

These findings provide strong experimental evidence that infants are able to use prior experiences with objects to segregate displays involving the objects. Such an ability is likely to be quite useful in a baby's world that is typically somewhat circumscribed. Thus, initially there would be much to do to gain familiarity with the blankets, stuffed animals, crib, chairs, tables, cups, bottles and other items that make up the environment at home (and perhaps daycare). However, because new items enter infants' world at a relatively slow rate (with the possible exception of an influx of toys around December!), it is reasonable to suppose that infants build up and maintain a knowledge base about the items they encounter in their homes. As each new item enters the infant's arena, she might actually see it quite veridically due to its contrast with familiar surrounding items.

The present results lead to a number of questions for future research. The first question concerns the length of time an experience with an object remains useful for segregation. In Experiment 5, we found that exposure to the box still contributed to the segregation process after a delay of 24 hours. Future experiments could investigate whether positive findings would also be obtained with longer delays. The results of such experiments might also shed light on the nature of the memory processes involved in these tasks. One strategy might be to compare the length of delay infants can tolerate in this paradigm with well-established forgetting functions for infants this age (e.g., Rovee-Collier et al.,

1980; Rovee-Collier, Greco-Vigorito, & Hayne, 1993; Rovee-Collier & Hayne, 1987).

A second question for future research concerns the conditions under which experiential knowledge can be used: would infants bring to bear a prior exposure not just to elucidate an ambiguous display, as in the present research, but also to adopt an alternative interpretation of a display? Consider, for example, the finding described in the introduction (Needham & Baillargeon, 1997) that 8-month-old infants see the cylinder-and-box display as composed of two separate units. What if infants this age were given a prior exposure to the display as a single unit (e.g., the cylinder and box would move together, making it clear that they are connected)? Would infants allow the interpretation suggested by the display's perceptual features (two units) to be overriden by that gained during their prior exposure to the display (one unit)? Furthermore, would infants respond in the same way if a delay of a day (or longer) was introduced between the prior exposure and the test session? Answering these questions will help determine how infants judge the relative reliabilities of featural and experiential information.

A third question for future research is whether infants' interpretation of a display would be affected by a prior exposure to an object similar, but not identical, to an object in the display (Needham, 1998). To illustrate, would 4.5-month-old infants perceive the cylinder-and-box display as composed of two separate units after being exposed to a box that shared some, but not all, of the features of the display box (e.g., a familiarization box of the same size and shape as the display box, but of a different color and pattern)? By systematically manipulating the similarities and differences in the features of the boxes shown in the familiarization and test events, we might learn more about (a) the features infants rely on to recognize objects and (b) the limits of infants' use of experiential knowledge in segregation tasks.

Evidence that infants' interpretation of a display is facilitated by a prior exposure to an object highly similar, but not moderately or weakly similar, to an object in the display, could lead to investigations of prior exposures involving object categories, rather than single objects. Let us assume, for example, that infants are found *not* to benefit from being exposed to a red, green, or purple box before seeing the blue box in the cylinder-and-box display. Would infants nevertheless be helped by being exposed to *all three* familiarization boxes before seeing the display? Could infants, in other words, categorize the three familiarization boxes on the basis of their common perceptual features, and then use this same category information to parse the cylinder-and-box display? The application of such category-based experiential knowledge to everyday segregation processes is intriguing. If an infant saw his mother carrying a red teddy bear on Tuesday, his sister cuddling a similar green bear on Wednesday, and a puppy chewing a similar purple bear on Thursday, would he perceive a similar blue bear as separate from an adjacent umbrella, even if he had never seen the blue bear or umbrella before? The approach suggested here is conceptually similar to that used by Rovee-Collier and her colleagues to study the interaction between memory and category membership in the mobile conjugate reinforcement paradigm (e.g., Rovee-Collier et al., 1993).

A fourth question to be addressed in future experiments concerns the discrepancy between the results of the present experiments and Piaget's (1952) oft-cited observations about the reaching behavior of his 6-month-old son, Laurent (for somewhat different observations, see Bresson, Maury, Pierault-Le Bonniec, & De Schonen, 1976). When Piaget held a matchbox on the tips of his fingers, Laurent was eager to grasp it. However, after Piaget placed the matchbox on top of a larger object such as a book, Laurent showed no interest in reaching for the matchbox that had previously captured his attention. Laurent's behavior suggests that his prior experience with the matchbox did not allow him to reach

for the matchbox as an object separate from the book.

There are at least two stances one might take with respect to the discrepancy between the present results and Piaget's (1952) observations. One stance would be to conclude that, in this as in several other areas of infant perception and cognition, paradigms that rely on infants' looking behavior are often more sensitive and more likely to reveal early abilities than are paradigms that rely on infants' actions upon objects (e.g., Baillargeon, 1993, 1994, 1995; Spelke, 1994). Another stance would be to point out that, although the specific procedure used by Piaget in his interactions with Laurent did not yield sophisticated reaching, it remains possible that variations of the reaching task would bring to light more object-appropriate behavior (such as that observed, for example, in experiments by Clifton, Rochat, Litovsky, & Perris, 1991; Hofsten, 1983; Hofsten & Fazel-Zandy, 1984; and Lockman, Ashmead, & Bushnell, 1984).

Previous experiments have documented young infants' difficulty in interpreting adjacent displays composed of two dissimilar objects (e.g., see Spelke, 1991). The present research indicates that young infants can succeed in segregating such a display if they are first exposed to one of the objects in the display. In general, this research suggests that, although they may lack configural knowledge, young infants are not continually surrounded by displays whose boundaries are uncertain. In their worlds, infants encounter many of the same objects from one day to the next; the present experiments indicate that infants can draw on these experiences to accurately perceive scenes of familiar and novel objects.

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NOTES

1. When tested with two- as opposed to three-dimensional displays, even 3-month-old infants show some sensitivity to featural information (e.g., Atkinson & Braddick, 1989; Bornstein & Krinsky, 1985; Colombo, Laurie, Martelli, & Hartig, 1984; Ghim, 1990; Giffen & Haith, 1984; Milewski, 1978; Quinn & Eimas, 1986; Quinn, Burke, & Rush, 1993; Treiber & Wilcox, 1980). See Needham and Baillargeon (in press-b) for an attempt at reconciling the discrepant results obtained with the two types of displays.
2. Although we will describe this memory process as one of recognition, there are alternative explanations for the influence of a prior exposure to an item on subsequent responses to that item that do not involve conscious recognition (e.g., Cave & Squire, 1992; McKee & Squire, 1993; Musen & Triesman, 1990; Naito, 1990). It is beyond the scope of the present paper to determine how conscious or unconscious, or how explicit or implicit, were the memory processes at work here; further research is necessary to shed light on these challenging issues.
3. In a pilot experiment conducted with the same apparatus, events, and procedure as Experiment 1, the primary observer (whose input was used to terminate the trials) was asked to guess at the end of each experimental session whether the infant had seen the move-together or the move-apart test event. The primary observer offered correct guesses for only 13 of the 27 infants tested, suggesting that observers' ability to determine infants' condition was at chance. In addition to being naive about the condition to which infants were assigned, observers were

often naive about the experiment in which infants were participating: many of the experiments described in the present paper (as well as other pilot experiments not reported here; see Needham, 1992) overlapped in time, and observers typically did not know to which of these experiments an infant had been assigned.

4. Due to computer error, the precise familiarization looking time of one of the infants in the move-together condition was lost; this infant was not included in the present analysis.

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