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# Intuitions about support in 4.5-month-old infants*

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**Abstract**

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*The present experiment examined whether 4.5-month-old infants expect an object to fall when its support is removed. The infants saw two test events: a possible and an impossible event. In the possible event, a hand deposited a box fully* on *a platform and then withdrew, leaving the box supported by the platform. In the impossible event, the hand deposited the box* beyond *the platform and then withdrew, leaving the box suspended in mid-air with no apparent source of support. The infants looked reliably longer at the impossible than at the possible event, suggesting that they expected the box to fall in the impossible event and were surprised that it did not. Evidence for this interpretation was provided by the results of two control conditions. In one, the box fell when released by the hand beyond the platform. In the other, the hand retained its grasp on the box throughout the events, thereby providing continuous support for it. The infants in these two conditions tended to look equally at the test events. Together, these results indicate that, like adults, 4.5-month-old infants realize that objects cannot remain stable without support.*

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### 1.1. Introduction

Until recently, investigations of young infants' understanding of the physical world typically focused on a single question: at what age do infants begin to share adults' belief that objects continue to exist when out of sight? Early attempts at answering this question yielded negative results. Evidence collected with manual search tasks led Piaget (1954) and others (see Gratch, 1976; Harris, 1987, 1989; and Schuberth, 1983, for reviews) to conclude that infants less than 9 months of age perceive objects, not as permanent entities that continue to exist when masked by other objects, but as transient entities that cease to exist as soon as they disappear from view.

However, subsequent experiments conducted with visual, non-search tasks revealed that even young infants realize that objects continue to exist when out of sight (e.g., Baillargeon, 1986, 1987a, 1987b, 1991, 1992a, 1992b; Baillargeon & DeVos, 1991; Baillargeon & Graber, 1987; Baillargeon, Graber, DeVos, & Black, 1990; Baillargeon, Spelke, & Wasserman, 1985; Spelke, Breinlinger, Macomber, & Jacobson, 1992a; Spelke & Kestenbaum, 1986). In one experiment (Baillargeon & DeVos, 1991), for example, 3.5-month-old infants were habituated to a toy carrot that slid back and forth along a horizontal track whose center was occluded by a screen. On alternate trials, the infants saw a short and a tall carrot move along the track. Following habituation, the mid-section of the screen's upper half was removed, and the infants saw two test events: a possible and an impossible event. In the possible event, the short carrot moved back and forth along the track; this carrot was shorter than the window's lower edge and hence did not appear in the window when passing behind the screen. In the impossible event, the tall carrot moved back and forth along the track; this carrot was taller than the window's lower edge and thus should have appeared in the screen window but did not in fact do so. The infants tended to look equally at the tall and the short carrot habituation events, but looked reliably longer at the impossible than at the possible test event. These results indicated that the infants (a) realized that each carrot continued to exist after it slid behind the screen; (b) assumed that each carrot retained its height behind the screen; (c) believed that each carrot pursued its trajectory behind the screen; and hence (d) expected the tall carrot to appear in the screen window and were surprised that it did not.

The results of this experiment and of related experiments (e.g., Baillargeon, 1986, 1987a, 1987b, 1991, 1992a, 1992b; Baillargeon & Graber, 1987; Baillargeon et al., 1985, 1990; Hood & Willatts, 1986; Clifton, Rochat, Litovsky, & Perris, 1991; Spelke & Kestenbaum, 1986; Spelke et al., 1992a) indicated that young infants' understanding of permanence is far more sophisticated than was traditionally assumed. Such evidence gave rise to the possibility that investigations of other facets of infants' physical world would uncover further competencies. Over the past few years, researchers have begun examining infants' intuitions about

support relations between objects (e.g., Baillargeon, 1992b; Baillargeon & Hanko-Summers, 1990; Baillargeon, Needham, & DeVos, 1992; Needham & Baillargeon, 1992; Spelke et al., 1992a; Spelke, Simmons Turner, Breinlinger, Jacobson, Keller, & Macomber, 1992b). The present research built on the results of some of these initial experiments.

### 1.2. Infants' intuitions about support

Adults possess sophisticated beliefs about support relations between objects. These beliefs enable them to place objects safely on tables and shelves, stack objects in cupboards and trunks, carry armfuls of groceries and books, improvise makeshift shelters and bridges, balance figurines at the top of Christmas trees and wedding cakes, and so on. Intuitions about support directly or indirectly permeate most of adults' interactions with objects.

Baillargeon and Hanko-Summers (1990) recently examined 8.5-month-old infants' ability to reason about support relations between objects. The infants saw a test event in which a small box was centered between and supported by two larger boxes. Neither larger box alone provided adequate support for the small box. During the event, the right box moved to the right, past the right edge of the small box, and then returned to its initial position. The small box failed to fall when the right box moved aside (it was secured, out of sight, to the back wall of the apparatus). Prior to seeing this test event, half of the infants (three-box condition) were given replicas of the three test boxes: the small box and the two larger boxes. The other infants (two-box condition) were given two boxes: the right larger box and an oddly shaped box corresponding to the left larger box with the small box attached to its top right corner, just as in the test event. The infants in the three-box condition looked reliably longer at the test event than the infants in the two-box condition. This result suggested that the infants in the three-box condition (a) believed that the small box could not remain stable without adequate support; (b) understood that the left box alone did not provide adequate support for the small box; and hence (c) were surprised that the small box did not fall when the right box was moved aside.

Would infants less than 8.5 months of age also be able to judge whether an object was adequately supported? A recent experiment addressed this question (Baillargeon et al., 1992). In this experiment, 6.5- and 5.5-month-old infants watched the extended index finger of a gloved hand push a box along the top surface of a platform. The infants saw two test events: a possible and an impossible event. In the possible event, the box was pushed until it reached the end of the platform. In the impossible event, the box was pushed until only its left corner remained on the platform. The results indicated that the 6.5-month-old infants looked reliably longer at the impossible than at the possible event,

suggesting that they (a) believed that the box could not remain stable without adequate support; (b) realized that the box was inadequately supported when only its left corner remained on the platform; and hence (c) expected the box to fall in the impossible event and were surprised that it did not. A control condition in which the hand grasped the box throughout the test events provided evidence for this interpretation.

In contrast to the 6.5-month-old infants, the 5.5-month-old infants tended to look equally at the impossible and the possible test events. One interpretation for this negative finding was that these younger infants considered *any* amount of contact between the box and the platform sufficient for the box to be supported. This interpretation left open the possibility that young infants might expect the box to fall if it had *no* contact with the platform. The present experiment was designed to test this possibility.

### 1.3. The present experiment

The present experiment examined whether 4.5-month-old infants expect an object to fall when its support is entirely removed. The infants were assigned to either the experimental or the control condition. The infants in the *experimental* condition saw two test events: a possible and an impossible event (see Figure 1). At the start of each event, a gloved hand held a box in mid-air to the right of a platform that rested on the floor of the apparatus. In the possible event, the hand deposited the box fully *on* the platform and then retreated a short distance, leaving the box supported by the platform. In the impossible event, the hand

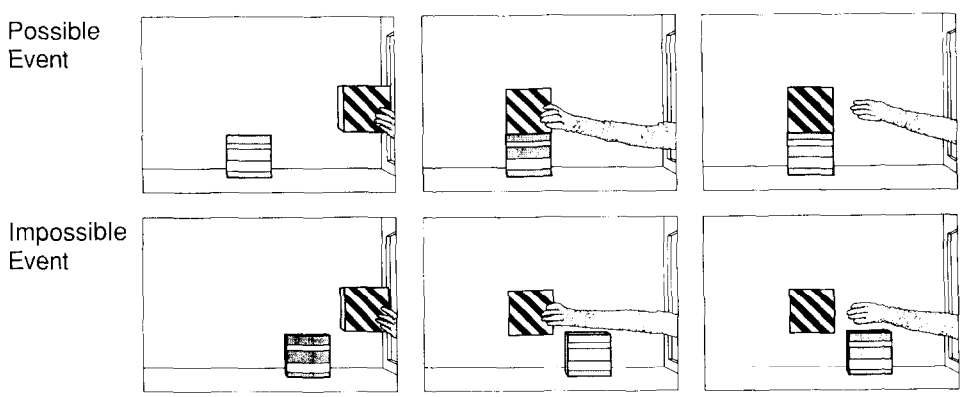


Figure 1. *Schematic representation of the events shown to the infants in the experimental condition in Experiment 1.*

deposited the box *beyond* the platform and then retreated, leaving the box suspended in mid-air with no apparent source of support.

The infants in the *control* condition saw two events that were identical to those shown to the infants in the experimental condition with one exception: the hand never released the box and so the box remained adequately supported throughout the test events.

Our reasoning was as follows. If the infants (a) understood that the box could not remain stable without support and (b) realized that the box was supported when it rested on the platform or was held by the hand but not when it was released in mid-air, then the infants in the experimental condition should be surprised that the box did not fall in the impossible event. Because infants typically react to surprising events with prolonged attention, we predicted that, if the infants in the experimental condition were surprised by the impossible event, they would look reliably longer at this event than at the possible event. In contrast, we expected the infants in the control condition to look equally at the off-platform and the on-platform events, because in both events the box was always adequately supported.

## 2. EXPERIMENT 1

### 2.1. Method

#### *2.1.1. Subjects*

Subjects were 20 healthy, full-term infants ranging in age from 4 months, 4 days to 4 months 25 days ($M$ = 4 months, 17 days). One additional infant was excluded from the experiment because of procedural error. The infants' names were obtained from birth announcements in the local newspaper. 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.

Half of the infants were assigned to the experimental condition ($M$ = 4 months, 17 days), and half were assigned to the control condition ($M$ = 4 months, 17 days).

#### *2.1.2. Apparatus*

The apparatus consisted of a wooden cubicle 201 cm high, 102 cm wide, and 39 cm deep. The infant faced an opening 55 cm high and 95 cm wide in the front wall of the apparatus. The floor of the apparatus was covered with pale green contact

paper, the side walls were painted white, and the back wall was covered with brightly lined white contact paper.

The infant was shown two objects: a platform that rested on the apparatus floor, and a box that an experimenter moved about the apparatus. This experimenter wore a bright red glove 61.5 cm long on her left hand and arm. The experimenter introduced her hand into the apparatus through an opening 51 cm high and 24 cm wide in the right wall. This opening was partially covered by a white muslin curtain.

The platform was 16 cm high, 16 cm wide, and 7 cm deep, and was covered with bright red contact paper decorated with white stripes. The platform was 48 cm from the right wall of the apparatus in the possible event, and was 26 cm from the same wall in the impossible event. In either event, the platform rested 26 cm from the front edge of the apparatus.

The box was 17 cm high, 16 cm wide, and 9 cm deep, and was covered with bright blue contact paper decorated with green stripes and gold stars. A wooden block 2 cm high, 4 cm wide, and 4 cm deep was attached to the center of the box's back surface. In its rightmost position, the box was held 16 cm above the floor of the apparatus, 26 cm from the front edge, and 6 cm from the right wall. In its leftmost position, the box was 16 cm above the floor of the apparatus, 26 cm from the front edge, and 48 cm from the right wall. When on the platform, the box's front and side edges were aligned with those of the platform.

In its leftmost position, the box stood in front of a small hidden door in the back wall of the apparatus. This door was 11 cm high and 9 cm wide and was located 16.5 cm above the floor of the apparatus. Unseen by the infant, a second experimenter could open the door behind the box and introduce a support device into the apparatus. This device consisted of a structure shaped like a "7"; the vertical portion of the device was 23 cm high, 7.5 cm wide, and 16.5 cm deep, and the horizontal portion was 4.5 cm high, 7.5 cm wide, and 23 cm deep. When the vertical portion of the device was placed against the back wall of the apparatus, the horizontal portion protruded into the apparatus, immediately beneath the block attached to the back of the box. By applying downward pressure on the block, the second experimenter was able to support the box from behind. This method was adopted (rather than having the second experimenter simply hold the block on the back of the box) because it ensured that the box did not quiver or jiggle when released by the first experimenter's hand.

The infant was tested in a brightly lit room. Four clip-on lights (each with a 40 W lightbulb) were attached to the back and side walls of the apparatus to provide additional light. Two wooden frames covered with black cloth, each 183 cm high and 71 cm wide, stood at an angle on either side of the apparatus. These frames served to isolate the infant from the experimental room. A muslin-covered frame 60 cm high and 101 cm wide was lowered in front of the opening in the front wall of the apparatus at the end of each trial.

### *2.1.3. Events*

Two experimenters worked in concert to produce the events. The first experimenter moved the box in the apparatus, and the second experimenter operated the support device. The numbers in parentheses correspond to the amount of time taken to perform each action.

#### *2.1.3.1. Experimental condition*

*Impossible event.* At the start of the impossible event, the first experimenter's hand held the box 6 cm from the right wall of the apparatus; the platform rested on the floor of the apparatus, 26 cm from the right wall. The hand moved the box to the left 42 cm, at a speed of about 21 cm/s (2 s). The hand then paused for 2 s, still gripping the box. During this pause, the second experimenter opened the hidden door in the back wall of the apparatus and inserted the support device beneath the block attached to the back of the box. Next, the first experimenter's hand released the box and retreated about 21 cm to the right (1 s), where it paused for 3 s. The hand then gripped the box again (1 s) and paused for 2 s. This pause allowed the second experimenter to remove the support device from the apparatus and close the hidden door in the back wall. The first experimenter's hand then moved the box back to its starting position (2 s), and paused for 1 s. Each event cycle thus lasted about 14 s. Cycles were repeated until the computer signaled that the trial had ended (see below). When this occurred, the second experimenter lowered the curtain in front of the apparatus.

*Possible event.* The possible event was identical to the impossible event except that the platform was positioned 48 cm from the right wall. The hand thus released the box on the platform rather than in mid-air.

#### *2.1.3.2. Control condition*

*Off-platform and on-platform events.* The off-platform and the on-platform events shown to the infants in the control condition were identical to the impossible and the possible events shown to the infants in the experimental condition, respectively, except that the hand never released the box.

The support device was used in all of the events to ensure that any faint sounds associated with its introduction and removal did not contribute to differences in the infants' looking times at the events.

### *2.1.4. Procedure*

Prior to the experiment, each infant was allowed to manipulate the red glove, the

platform, and a replica of the box that did not have a block attached to its back surface. The infant manipulated these objects for a few minutes while his or her parent filled out consent forms. During the experiment, the infant sat on his or her parent's lap in front of the apparatus. The infant's head was approximately 86 cm from the platform. The parent was instructed to remain neutral and to close his or her eyes during the trials.

The infant's looking behavior was monitored by two observers who watched the infant through peepholes in the cloth-covered frames on either side of the apparatus. The observers did not know the order in which the events were presented. Each observer held a button connected to a DELL computer 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 averaged 90% or more per trial per infant. The looking times recorded by the primary observer were used to determine when a trial had ended (see below).

The infants in the experimental condition saw the impossible and the possible events described above on alternate trials until they completed four pairs of test trials. Similarly, the infants in the control condition saw the off-platform and the on-platform events described above on alternate trials until they completed four test pairs. In each condition, order of presentation of the two test events was counterbalanced. Each test trial ended when the infant either (a) looked away from the event for 2 consecutive seconds after having looked at it for at least 5 cumulative seconds or (b) looked at the event for 60 cumulative seconds without looking away for 2 consecutive seconds. The 5 s value was chosen because it was the minimum looking time necessary to distinguish between the impossible and the possible events.

Only one of the 20 infants in the experiment failed to complete all four pairs of test trials. This infant completed only three pairs, because of fussiness. In this experiment as in the following experiments, all infants were included in the data analyses, whether or not they completed all four pairs of test trials. Preliminary analyses revealed no significant interaction involving order (impossible/off-platform event first or possible/on-platform event first) and event, all $Fs < 1.80$, $p > .05$. The data were therefore collapsed in subsequent analyses.

### 2.2. Results

The left-hand side of Figure 2 shows the difference in the mean looking times of the infants in the experimental condition at the impossible and the possible events. It can be seen that all but one of the infants looked longer at the

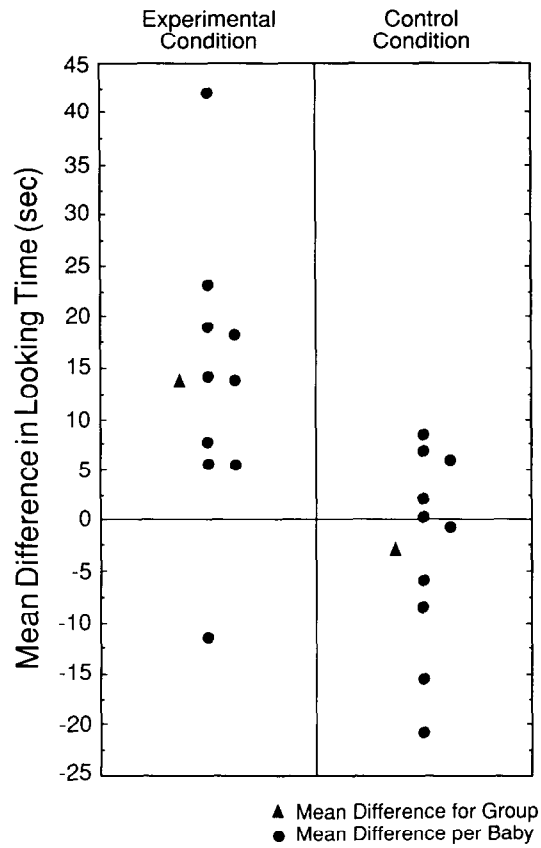


Figure 2. *Differences in the mean looking times at the test events of the infants in the experimental and the control conditions in Experiment 1. (Each dot represents an individual subject. A positive score signifies a longer mean looking time at the impossible/off-platform than at the possible/on-platform event; a negative score, in contrast, signifies a longer mean looking time at the possible/on-platform event.)*

impossible than at the possible event. The right-hand side of Figure 2 shows the difference in the mean looking times of the infants in the control condition at the off-platform and the on-platform events. It can be seen that less than half of the infants looked longer at the off-platform than at the on-platform event.

The infants' looking times were analyzed by means of a mixed-model analysis of variance, with condition (experimental or control) as the between-subjects factor and with event (impossible/off-platform or possible/on-platform event) and test pairs (pairs 1 through 4) as the within-subjects factors. Because the design was unbalanced, the SAS GLM procedure was used to calculate the ANOVA (SAS Institute, 1986). There was a reliable main effect of event, $F(1, 71) = 4.41$, $p < .05$, and a reliable Condition × Event interaction, $F(1, 71) = 10.17$, $p < .005$. Planned comparisons indicated that the infants in the experimen-

tal condition looked reliably longer at the impossible ($M = 37.2$) than at the possible ($M = 23.6$) event, $F(1, 71) = 13.97$, $p < .0005$, whereas the infants in the control condition tended to look equally at the off-platform ($M = 24.5$) and at the on-platform ($M = 27.3$) events, $F(1, 71) = 0.60$.

The analysis also revealed a significant main effect of test pair, $F(3, 53) = 3.56$, $p < .05$, indicating that the infants looked reliably less as the experiment progressed.

### 2.3. Discussion

The infants in the experimental condition looked reliably longer at the impossible than at the possible event, suggesting that they (a) believed that the box could not remain stable without support; (b) realized that the box was supported when it rested on the platform or was held by the hand, but not when it was released in mid-air; and hence (c) expected the box to fall in the impossible event and were surprised that it did not.

In contrast to the infants in the experimental condition, the infants in the control condition tended to look equally at the off-platform and the on-platform events. These results provided evidence against several alternative interpretations of the results of the experimental condition. In particular, it was unlikely that the infants in this condition looked reliably longer at the impossible than at the possible event because they preferred the platform in its right rather than its left location, because they enjoyed the box and the platform more as two separate objects than as two adjacent objects (or as a single, composite object), or, more generally, because they found the configuration of the box and the platform in the impossible event more pleasing than that in the possible event.

However, there were still two alternative interpretations for the results of the experimental condition that were not directly addressed by the results of the control condition. One explanation was that the infants looked reliably longer at the impossible than at the possible event, not because they were surprised that the box did not fall when it was released by the hand beyond the platform, but because they had never before witnessed the deliberate release of an object in mid-air. According to this explanation, the infants had no concept of support and no particular expectation for what the box should do when released in mid-air; they were merely interested in watching this novel occurrence. This interpretation was addressed in Experiment 1A.

The second alternative explanation for the results of the experimental condition was that the infants looked reliably longer at the impossible event because they had never seen an object suspended in mid-air, without contact with any other surface, either horizontal (e.g., table) or vertical (e.g., wall). Such an explanation would again invalidate the claim that the infants in the experimental

condition expected the box to fall when unsupported and were surprised that it did not. This interpretation was investigated further in Experiment 1B.

## 3. EXPERIMENT 1A

Could the infants in the experimental condition in Experiment 1 have looked reliably longer at the impossible than at the possible event because they had never before witnessed the deliberate release of an object in mid-air? Although caretakers often drop objects into containers (e.g., carrots in a pan, cheerios in a bowl, clothes in a laundry basket), they are less likely to drop objects onto open surfaces (one exception is that of dropping a ball to bounce it, but that is a game caretakers rarely engage in with 4.5-month-old infants). In addition, infants themselves are incapable of deliberately releasing objects until fairly late in the first year of life year of life (e.g., Piaget, 1952). It was therefore plausible that the performance of the infants in the experimental condition in Experiment 1 reflected surprise at the release of the box in mid-air, rather than surprise at the box's failure to fall when released.

To address this possibility, we conducted an experiment that tested whether 4.5-month-old infants did, in fact, expect the box to fall when released by the hand beyond the platform. The infants in Experiment 1A saw two test events. One (box-on-platform event) was identical to the possible event shown to the infants in the experimental condition in Experiment 1. The other (box-falls event) was similar to the impossible event shown to the infants in the experimental condition with one exception: when released beyond the platform, the box fell to the floor of the apparatus.

Our reasoning was as follows. If the infants in the experimental condition in Experiment 1 looked reliably longer at the impossible than at the possible event because they were surprised to see the hand deliberately release the box in mid-air, then the infants in Experiment 1A should look reliably longer at the box-falls event than at the box-on-platform event. On the other hand, if the infants in the experimental condition in Experiment 1 looked longer at the impossible event because they expected the box to fall and were surprised that it did not, then the infants in Experiment 1A should look equally at the box-falls and the box-on-platform events, because neither event violated their intuitions about support.

### 3.1. Method

#### *3.1.1. Subjects*

Subjects were 8 healthy, full-term infants ranging in age from 4 months, 4 days to 4 months, 29 days ($M = 4$ months, 12 days).

### 3.1.2. Apparatus

The apparatus used in Experiment 1A was the same as in Experiment 1 with two exceptions. One was that small magnets were attached to the bottom of the box. The other exception was that a thin metallic strip 25 cm wide and 14 cm deep was placed on the apparatus floor during the box-falls event. This metal strip was covered with the same contact paper as the apparatus floor and so was not readily detectable. When released by the hand, the box fell on the strip; the box's magnets prevented any further motion (e.g., bouncing) from occurring.

### 3.1.3. Events

The first experimenter produced the events without the help of the second experimenter, as the support device was not used in Experiment 1A. As before, the numbers in parentheses correspond to the time taken to perform each action.

*Box-falls event.* The box-falls event was similar to the impossible event shown to the infants in the experimental condition in Experiment 1 with the following exceptions. Instead of pausing for 2 s before releasing the box, the hand now paused for 1 s and then lowered the box approximately 8 cm (1 s). When released, the box thus fell about 8.5 cm onto the (hidden) metal strip on the apparatus floor. Similarly, instead of grasping the box (1 s) and then pausing for 2 s, the hand now grasped the box (1 s), raised it about 16 cm above the apparatus floor (1 s), and then paused for 1 s. The box-falls event thus lasted about 14 s, just as the impossible event in Experiment 1.

*Box-on-platform event.* The box-on-platform event was identical to the possible event shown to the infants in the experimental condition in Experiment 1.[1]

### 3.1.4. Procedure

The procedure in Experiment 1A was identical to that in Experiment 1. The infants saw the box-falls event and the box-on-platform events on alternate trials

[1]One might be concerned that the observers in this experiment could hear the box fall on the apparatus floor in the box-falls event and could therefore determine the order in which the two test events were presented. To make sure this did not affect the results, half of the infants were presented with the box-on-platform event accompanied by the falling sound that occurred during the box-falls event. To produce this effect, an experimenter dropped a box immediately behind the back wall of the apparatus, creating a sound indistinguishable (in timing as well as location) from the sound in the box-falls event. Preliminary analyses indicated no differences between the looking times of the infants who heard the falling sound during the box-on-platform event and the infants who did not. Therefore, the data were collapsed for subsequent analyses.

until they had completed four pairs of test trials. Half of the infants saw the box-falls event first and half saw the box-on-platform event first. Preliminary analyses revealed no significant interaction involving order (box-falls event first or box-on-platform event first) and event, both $Fs < 2.69$, $p > .05$. The data were therefore collapsed in subsequent analyses.

### 3.2. Results

Figure 3 shows the difference in the infants' mean looking times at the box-falls and the box-on-platform events. It can be seen that half of the infants preferred the box-falls event and half preferred the box-on-platform event.

The looking times of the infants in Experiment 1A were compared to those of

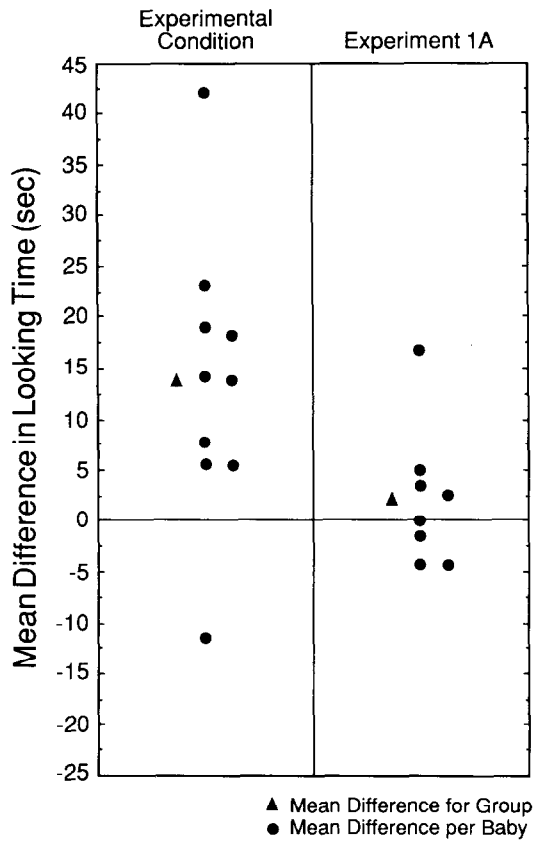


Figure 3. *Differences in the mean looking times at the test events of the infants in the experimental condition in Experiment 1 and the infants in Experimental 1A. (Each dot represents an individual subject. A positive score signifies a longer mean looking time at the impossible/box-falls than at the possible/box-on-platform event; a negative score, in contrast, signifies a longer mean looking time at the possible/box-on-platform event.)*

the infants in the experimental condition in Experiment 1 by means of a $2 \times 2 \times 4$ mixed-model analysis of variance with experiment (1 or 1A) as the between-subjects factor and with event (impossible/box-falls or possible/box-on-platform event) and test pair (pairs 1 through 4) as the within-subjects factors. There was a significant main effect of event, $F(1, 63) = 7.56$, $p < .01$, and a significant Experiment × Event interaction, $F(1, 63) = 4.38$, $p < .05$. Planned comparisons confirmed that the infants in the experimental condition in Experiment 1 looked reliably longer at the impossible ($M = 37.2$) than at the possible ($M = 23.6$) event, $F(1, 63) = 13.15$, $p < .001$, whereas the infants in Experiment 1A tended to look equally at the box-falls ($M = 35.5$) and the box-on-platform ($M = 33.7$) events, $F(1, 63) = 0.20$. The analysis also revealed a reliable main effect of test pair, $F(3, 47) = 3.02$, $p < .05$, indicating that the infants looked reliably less as the experiment progressed.

### 3.3. Discussion

The infants in Experiment 1A tended to look equally at the box-falls and the box-on-platform events. This result refuted the hypothesis that the infants in the experimental condition in Experiment 1 looked reliably longer at the impossible than at the possible event because they found the hand's deliberate release of the box in mid-air interesting or novel. Together, the results of Experiments 1 and 1A suggested that the infants expected the box to fall when released by the hand beyond the platform, and were surprised that it did not.

There was, however, one alternative interpretation for the results of Experiments 1 and 1A. As was mentioned earlier, it was possible that the infants in the experimental condition in Experiment 1 looked reliably longer at the impossible than at the possible event simply because they had never before seen an object suspended in mid-air, without contact with any other object. In the events shown to the infants in the control condition in Experiment 1, the box was always in contact with either the hand or the platform; in the events shown to the infants in Experiment 1A, the box was in contact with the hand, the platform, or the floor of the apparatus, except during the very brief moment in which it fell to the floor of the apparatus. It was thus logically possible that the performance of the infants in the experimental condition in Experiment 1 reflected their surprise at seeing for several seconds at a time an object without contact with any other object, rather than their surprise at seeing an object remain stable after its support was removed.

This alternative interpretation seemed to us unlikely, for two reasons. First, young infants may occasionally encounter objects in their daily environments that are stable and yet appear unsupported: shades on floorlamps, ceiling fans, lamps suspended in front of walls, or even hanging plants could all seem to be

free-floating in space when viewed in such a way that their supports are not visible. Second, young infants are no doubt frequently faced with scenes in which objects appear, for brief intervals, to be unsupported. Consider, for example, a father who is carrying a laundry basket in such a way that his hands are hidden from his infant's view. The infant would perceive that the basket and the father's body are separated in depth, with no visible connection between them. Many similar scenes could be imagined: a mother holding a pot in such a way that her hand on the pot's handle is invisible; a sibling waving a teddy bear in such a way that his hands are hidden by the toy; and so on. In each case, the infant would experience an object that is apparently suspended in mid-air, until some further movement revealed the hand(s) holding the basket, pot, or bear.

Given this line of reasoning, it seemed to us improbable that the infants in the experimental condition in Experiment 1 looked longer at the impossible event because they were surprised to see for several seconds at a time an object without visible contact with any other object. To provide more direct evidence against this interpretation, however, we decided to conduct an additional control experiment. Subjects were again 4.5-month-old infants. The infants in Experiment 1B saw two static displays. In one (on-platform display), the box rested on the platform, as in the possible event shown to the infants in the experimental condition in Experiment 1. In the other display (off-platform display), the box stood suspended in mid-air to the left of the platform, as in the impossible event shown to the infants in the experimental condition in Experiment 1.

Our reasoning was as follows. If the infants in the experimental condition in Experiment 1 looked reliably longer at the impossible than at the possible event because of the sheer perceptual novelty of seeing an object not in physical contact with any other object, then the infants in Experiment 1B should also look reliably longer at the off-platform than at the on-platform display. On the other hand, if the infants in the experimental condition looked longer at the impossible event because they were surprised that the box did not fall when it was released by the hand beyond the platform, then it was plausible that the infants in Experiment 1B would look equally at the off-platform and the on-platform events. In the experimental condition, the infants were presented with an unambiguous situation: the box was initially supported, in full view, by the hand, and this support was subsequently replaced by that of the platform (possible event), or was removed entirely (impossible event). In Experiment 1B, in contrast, the infants were faced with an ambiguous situation comparable to the apparent support violations mentioned a moment ago. The box was suspended in front of the apparatus's back wall in the same way that a teddy bear might appear suspended in front of a sibling's smiling countenance. A situation involving the removal of an object's known source of support, we speculated, might be perceived by young infants very differently from a situation in which no information was directly available about an object's source of support.

## 4. EXPERIMENT 1B

### 4.1. Method

#### 4.1.1. Subjects

Subjects were 8 healthy, full-term infants ranging in age from 4 months, 5 days to 4 months, 28 days ($M = 4$ months, 11 days).

#### 4.1.2. Apparatus

The apparatus used in Experiment 1B was the same as in Experiment 1.

#### 4.1.3. Displays

*Off-platform display.* In the off-platform display, the box stood suspended in mid-air to the left of the platform, just as in the impossible event shown to the infants in the experimental condition in Experiment 1. The box was held in position by the support device introduced through the hidden door in the apparatus's back wall, as in Experiment 1. The hand did not enter the apparatus, and the box and the platform remained stationary.

*On platform display.* In the on-platform display, the box rested on the platform, just as in the possible event shown to the infants in the experimental condition in Experiment 1. Again, the hand did not enter the apparatus, and the box and the platform remained stationary.

#### 4.1.4. Procedure

The procedure used in Experiment 1B was identical to that in Experiment 1. The infants saw the off-platform and the on-platform displays on alternate trials until they completed four pairs of trials. Half of the infants saw the off-platform display first, and half saw the on-platform display first. Each trial ended when the infant either (a) looked away from the display for 2 consecutive seconds after having looked at it for at least 3 cumulative seconds or (b) looked at the display for 60 cumulative seconds without looking away for 2 consecutive seconds. One infant did not complete all four test pairs; this infant completed only three pairs, due to procedural error. Preliminary analyses revealed no significant interaction involv-

ing order (off-platform display first or on-platform display first) and event, both $Fs < 1.15$, $p > .05$. The data were therefore collapsed in subsequent analyses.

### 4.2. Results

Figure 4 shows the difference in the mean looking times of the infants in Experiment 1B at the off-platform and the on-platform displays. It can be seen that nearly half of the infants looked about equally at the two displays, while the other infants had small preferences for one display or the other.

The looking times of the infants in Experiment 1B were compared to those of the infants in the experimental condition in Experiment 1 by means of a $2 \times 2 \times 4$

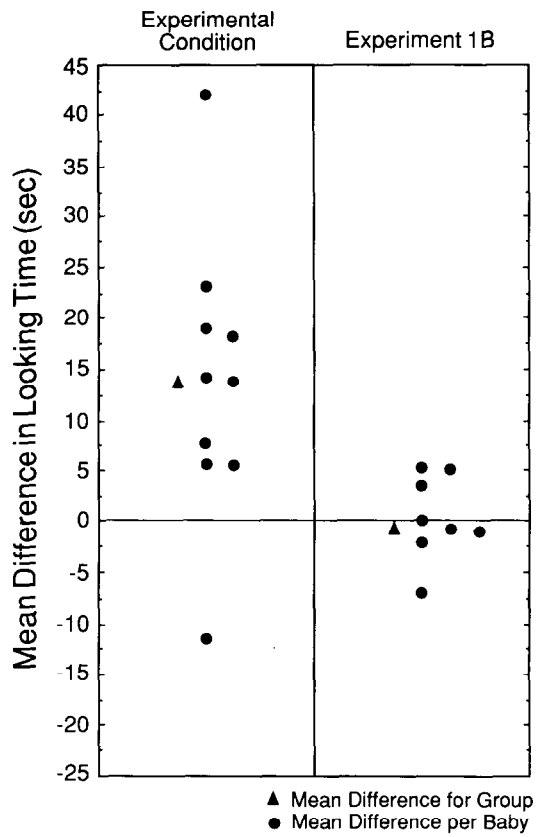


Figure 4. *Differences in the mean looking times at the test events of the infants in the experimental condition in Experiment 1 and the infants in Experiment 1B. (Each dot represents an individual subject. A positive score signifies a longer mean looking time at the impossible/off-platform than at the possible/on-platform event; a negative score, in contrast, signifies a longer mean looking time at the possible/on-platform event.)*

mixed-model analysis of variance with experiment (1 or 1B) as the between-subjects factor and with event (impossible/off-platform or possible/on-platform event) and test pair (pairs 1 through 4) as the within-subjects factors. There were significant main effects of experiment, $F(1, 16) = 28.94$, $p < .0001$, and event, $F(1, 108) = 5.67$, $p < .05$, as well as a significant Experiment × Event interaction, $F(1, 108) = 7.34$, $p < .01$. Planned comparisons confirmed that the infants in the experimental condition in Experiment 1 looked reliably longer at the impossible ($M = 37.2$) than at the possible ($M = 23.6$) event, $F(1, 108) = 14.83$, $p < .001$, whereas the infants in Experiment 1B tended to look equally at the off-platform ($M = 11.8$) and the on-platform ($M = 12.6$) displays, $F(1, 108) = 0.05$.

### 4.3. Discussion

The infants in Experiment 1B looked about equally at the off-platform and the on-platform displays. This result indicated that the infants in the experimental condition in Experiment 1 looked reliably longer at the impossible than at the possible event, not because they were intrigued to see the box suspended without visible contact with any other object, but because they were surprised that the box did not fall when released in mid-air.

Beyond providing an important control for the results of Experiment 1, the results of Experiment 1B also have interesting methodological and theoretical implications of their own; these are discussed in the next section.

## 5. DISCUSSION OF RELATED FINDINGS

The infants in the experimental condition in Experiment 1 looked reliably longer at the impossible than at the possible event, suggesting that they expected the box to fall when released in mid-air and were surprised that it did not. Control results from Experiments 1, 1A, and 1B confirmed that the infants looked longer at the impossible event, not because they preferred the arrangement of the box and the platform in this event to that in the possible event, not because they enjoyed watching the hand release the box in mid-air, and not because they were intrigued to see the box suspended without visible contact with any other object, but because they were surprised that the box remained stable when released by the hand beyond the platform.

These results provide evidence that infants as young as 4.5 months of age possess intuitions about support. We have recently completed an experiment whose results indicate that even 3-month-old infants hold similar intuitions (Needham & Baillargeon, 1992). The method used in this experiment was similar to that devised by Baillargeon et al. (1992) (see Introduction). The infants saw a

possible and an impossible test event in which the index finger of a gloved hand pushed a box from left to right along the top surface of a platform. In the possible event, the box was pushed until it reached the end of the platform. In the impossible event, the box was pushed completely off the platform and remained suspended in mid-air. The infants looked reliably longer at the impossible than at the possible event, suggesting that they were surprised that the box did not fall when pushed off the platform. The results of two control conditions confirmed this interpretation.

The present results, together with those of Baillargeon et al. (1992) and Needham and Baillargeon (1992), thus provide converging evidence that young infants possess intuitions about support. Such evidence contrasts, however, with recent reports from Spelke's laboratory (Spelke et al., 1992a, 1992b) that young infants do not expect objects to fall when unsupported. These reports involve three different experiments, all of which yielded negative results. In what follows, we describe each experiment in turn. As will be seen shortly, the three experiments made use of objects, events, and/or procedures different from those in the present experiment and in the experiments of Baillargeon et al. (1992) and Needham and Baillargeon (1992). Although it is possible that these methodological differences are responsible for the discrepancy between our results and those reported by Spelke and her colleagues, our own intuition is that this discrepancy stems from other, more interesting factors having to do with the precise nature of the support violations used in the experiments. Consideration of these factors, we believe, not only helps resolve the discrepancy between the results obtained in our laboratory and Spelke's, but also underscores at once the limitations and sophistication of infants' reasoning about support relations between objects.

In the *first* experiment we will describe (Spelke et al., 1992a, Expt. 4), 4-month-old infants were habituated to an event in which a hand released a ball above a screen; the ball then fell behind the screen. After a few seconds, the screen was removed to reveal the ball resting on a horizontal surface above the floor of the apparatus. Following habituation, the horizontal surface was removed, and the infants saw a possible and an impossible test event. In the possible event, the ball was revealed on the apparatus floor when the screen was removed. In the impossible event, the ball was revealed in the same position it occupied in the habituation event; because the horizontal surface was no longer present, however, the ball now appeared to be floating in mid-air. The infants tended to look equally at the impossible and the possible events, suggesting that they were not surprised, when the screen was removed, to see the ball suspended in mid-air.

How can we account for these negative results? One possibility is suggested by a comparison of the impossible event used by Spelke et al. (1992a, Expt. 4) with that shown in Experiment 1B. In the impossible event devised by Spelke et al., a hand released a ball which then fell behind a screen; after a few seconds, the

screen was removed to reveal the ball floating in mid-air. The initial part of the event (hand releases ball, ball falls) was of course consistent with the laws of gravity; only the latter part of the event (screen is raised to reveal ball suspended in mid-air) was not. Interestingly, this latter part shows a striking similarity to the impossible event used in Experiment 1B: recall that the curtain was raised, at the start of the event, to reveal the box suspended in mid-air.

What should be made of the fact that *both* the infants in the experiment of Spelke et al. (1992a, Expt. 4) and in Experiment 1B, who were tested with similar impossible events, failed to show reliable surprise at the events? On the one hand, one might propose that support violations involving static displays are less likely to engage infants' interest than more dynamic events. However, a more intriguing and, we believe, more likely hypothesis is that infants initially perform better when shown violations involving visibly supported objects that *lose* their support and yet remain stable, as opposed to violations involving unsupported, stable objects. On this view, infants would at first respond to support violations only if they (a) identified the source of an object's support (e.g., the box is supported by the hand or the platform) and then (b) observed this support being withdrawn with impunity (e.g., the box remains stable when released by the hand or when pushed off the platform).

Why young infants should be more likely to reveal their knowledge of support when shown an object losing its support without effect than when shown an apparently unsupported object (the latter being after all the end result of the former) is as yet unclear. Perhaps this difference points to the limits of young infants' knowledge about support. As they look about them, infants must see instances of many different types of support phenomena: hands holding and releasing toys, dishes stacked on tables, pictures, mirrors, and shelves resting on walls, fans suspended below ceilings, shades apparently floating above floorlamps, and so on. It might be proposed that, through their observations and manipulations, infants progressively form beliefs or expectations about these diverse phenomena. By 3–4 months of age, infants would appreciate that an object typically falls when released in mid-air or pushed off a supporting surface. They would, however, show little or no response when suddenly faced with a stable yet apparently unsupported object; such a display, like that of a lamp suspended below a ceiling or in front of a wall, would still fall within the range of uncharted phenomena – phenomena about which infants would know too little to distinguish violations from non-violations.

Whatever the explanation for young infants' consistent lack of response to static displays involving apparently unsupported objects, there is evidence that, by 6 months of age, infants already show reliable surprise at such displays. In another experiment, Spelke et al. (1992b, Expt. 1) tested 6-month-old infants with the same procedure Spelke et al. (1992a, Expt. 4) used with their 4-month-old subjects. The results indicated that these older infants looked reliably longer

at the impossible than at the possible event. Furthermore, their performance was reliably different from that of infants who saw control test events. These results suggest that the range of support violations infants respond to at 6 months of age is greater than that at 3 or 4 months. Such a conclusion is of course consistent with the results of Baillargeon et al. (1992) described in the Introduction.

Let us now turn to the *second* experiment reported by Spelke (Spelke et al., 1992b, Expt. 2) whose results are inconsistent with the present results as well as with those of Baillargeon et al. (1992) and Needham and Baillargeon (1992). In this experiment, 6-month-old infants were habituated to an event in which a ball rolled from left to right along the upper of two horizontal surfaces and disappeared behind a screen that hid the right end portion of the two surfaces. After a few seconds, the screen was removed to reveal the ball resting on the upper surface, against the right wall of the apparatus. Following habituation, a gap considerably wider than the ball was created in the upper surface, behind the screen, and the infants saw a possible and an impossible test event. The possible event was similar to the habituation event except that the ball rolled along the lower of the two surfaces. The impossible event was identical to the habituation event: the ball rolled along the upper surface and disappeared behind the screen; when the screen was removed, the ball was revealed on the same surface, to the right of the gap. The infants did not show a reliable preference for the impossible over the possible event, suggesting that they were not surprised, when the screen was removed, to see the ball resting *past* the gap in the apparatus's upper surface.

How should one account for these negative findings? Perhaps one might build on the explanation offered above for the negative results obtained in Experiment 1B and in Spelke et al. (1992a, Expt. 4). Specifically, one could propose that infants initially have difficulty reasoning about support violations that involve either (a) static displays or (b) dynamic events that take place out of view. Recall that the infants in the experiment by Spelke et al. (1992b, Expt. 2) did not *see* the ball roll above the gap in the impossible event but had to *infer* this motion from the ball's final position. This situation contrasts with that used in the present experiment as well as in Needham and Baillargeon (1992) and Baillargeon et al. (1992): in all of these cases, the support violations occurred in the infants' full view.

If valid, the conclusion that infants initially perform better with visible as opposed to hidden support violations would point to a dramatic difference in young infants' reasoning about support and about other properties of objects, such as their impenetrability. There is considerable evidence that young infants have no difficulty reasoning about impenetrability violations that take place out of sight (e.g., Baillargeon, 1986, 1987a, 1987b, 1991, 1992a; Baillargeon & DeVos, 1991; Baillargeon et al., 1985, 1990; Spelke et al., 1992a, Expts. 1, 2, and 3). One of these experiments is of special interest because it made use of a method superficially similar to that used by Spelke et al. (1992b, Expt. 2).

In this experiment (Spelke et al., 1992a, Expt. 2), 4-month-old infants were habituated to an event in which a hand dropped a medium-sized ball behind a screen; after a few seconds, the screen was removed to reveal the ball resting on the lower of two horizontal surfaces, beneath a gap in the upper surface that was wider than the ball. Following habituation, the infants saw a possible and an impossible test event that were identical to the habituation event except that two new balls were introduced. In the possible event, the ball was smaller than the habituation ball; in the impossible event, the ball was larger than both the habituation ball and the gap in the apparatus's upper surface. The infants looked reliably longer at the impossible than at the possible event. These and control results indicated that the infants (a) believed that each ball continued to exist, retained its size, and pursued its trajectory behind the screen; (b) were aware that the large ball was larger than the gap and hence should stop against it; and (c) realized, upon seeing the large ball under the gap, that the ball, instead of stopping against the gap, had somehow passed through it.

The discrepancy between these results and the results of the support experiment described above (Spelke et al., 1992b, Expt. 2) led Spelke (Spelke et al., 1992a, 1992b) to propose that the belief that objects are impenetrable is a part of infants' innate conception of objects, whereas the belief that objects require support to remain stable is a learned, fragile, and late-developing accomplishment.

However, one could offer another interpretation for this discrepancy and more specifically for the negative results Spelke et al. (1992b, Expt. 2) obtained with their 6-month-old infants. This explanation has to do with the fact that infants sometimes fail to show surprise at impossible events, not because their physical knowledge is lacking, but because their encoding of the events does not lead them to focus on the relevant aspects of the events (e.g., Baillargeon & DeVos, 1992; Kotovsky, Baillargeon, & Mangione, 1992). For example, in one experiment (Kotovsky et al., 1992), 6.5-month-old infants watched an impossible event involving an impenetrability violation: a screen that appeared to rotate through the space occupied by a large doll. For the infants in the *occlusion* condition, the impossible event began with the screen lying flat against the apparatus floor, toward the infants; the doll stood clearly visible behind the screen. The screen was then rotated 180° about its distant edge until it lay flat against the apparatus floor, toward the back wall. As it underwent its rotation, the screen first occluded and then appeared to rotate through the doll. The infants in the *disocclusion* condition saw the same impossible event in reverse: the screen first lay flat against the apparatus floor, toward the back wall, and was rotated forward 180° to reveal the doll standing intact behind it. Only the infants in the occlusion condition gave reliable evidence of being surprised at the impossible event they were shown. The authors speculated that the infants in the disocclusion condition failed to encode that the screen lay flat against the apparatus floor at the start of the event and

hence could have no object hidden beneath it. In a subsequent experiment, 6.5-month-old infants were again shown the disocclusion impossible event. Prior to seeing this event, however, the infants received two trials in which they saw two identical screens placed side by side, one lying flat against the apparatus floor, toward the back wall, and the other resting against the (hidden) doll. Kotovsky et al. reasoned that these trials might help the infants, at the start of the impossible event, focus on the fact that the screen lay flat against the apparatus floor and hence could have no object hidden under it. The results supported this analysis: the infants now showed reliable surprise at the disocclusion impossible event.

To see the relevance of these results to those obtained by Spelke with her 4-month-old (Spelke et al., 1992a, Expt. 2) and 6-month-old (Spelke et al., 1992b, Expt. 2) subjects, consider the habituation and test events shown to each group. The 4-month-old infants were habituated to a medium-sized ball passing through a gap and were tested with a smaller and a larger ball passing through the same gap. The habituation event was thus well designed to focus the infants' attention on the issue of whether each of the test balls could go through the gap. Contrast these events with those shown to the 6-month-old infants. These subjects were habituated to a ball rolling from left to right on the top of two surfaces. They were then tested with an event in which the ball rolled along the bottom surface, and an event in which the ball rolled along the top, now incomplete, surface. The infants in this experiment could have failed to look reliably longer at the impossible than at the possible event, not because they lacked the necessary physical knowledge, but because at least part of their attention was focused on which of the two surfaces the ball rolled on, rather than on the introduction of the gap in the top surface and its implications for the ball's motion. According to this analysis, the infants' performance would thus be similar to that of the 6.5-month-old infants in the experiment by Kotovsky et al. (1992), who failed to detect the surprising nature of the disocclusion impossible event because they failed to attend to the pertinent aspects of the event.

Let us now consider the *third* and last experiment reported by Spelke (Spelke et al., 1992b, Expt. 3) whose results are incompatible with the present results and with those of Baillargeon et al. (1992) and Needham and Baillargeon (1992). In this experiment, 6-month-old infants were habituated to an event in which a hand lowered a ball onto the top of two horizontal surfaces and then released the ball. Following habituation, the top surface was removed and the ball was either lowered to the bottom surface and released (possible event) or lowered to the position it occupied in the habituation event and released (impossible event). The infants tended to look equally at the two test events, suggesting that they were not surprised in the impossible event to see the ball remain suspended in mid-air when released by the hand.

These results are especially puzzling because the impossible event shown to the infants (hand releases ball, ball remains in place) is similar to that used in the

experimental condition in Experiment 1 (hand releases box, box remains in place). To explain these discrepant results, one might as always point to the methodological differences between the two experiments – the fact that Spelke et al. used habituation trials and we did not, the fact that Spelke et al. showed the impossible event only once per trial whereas we showed it repeatedly in each trial, and so on. However, we would like to raise another possibility, namely, that the infants in the experiment by Spelke et al. failed to show surprise at the impossible event because they were able to arrive at an explanation for how the event was contrived.

To produce their habituation and test events, Spelke et al. (1992b, Expt. 3) used a foam rubber ball mounted on a long wooden rod that protruded through the back wall of the apparatus, where it was held by the experimenter. Could it be that something about the motion of the ball in these events (e.g., the motion of the rod through the curtained openings in the back wall of the apparatus) clued the infants to the presence of the hidden rod?[2] There is evidence that in some situations infants fail to show surprise at impossible events because they are able to produce an explanation for the events (see Baillargeon, 1992b, for a review). One such situation is of particular relevance here. In one experiment (Baillargeon, 1992b), 9.5-month-old infants were tested with the same procedure Baillargeon et al. (1992) used with their 6.5-month-old infants. The results indicated that, in contrast to the younger infants, the 9.5-month-old infants were *not* surprised that the box remained stable when only its left corner rested on the platform. Through a process of elimination, Baillargeon eventually arrived at the hypothesis that these older infants were not surprised by the impossible event because they were able to use clues in the experimental situation to infer that the box had a hidden means of support (e.g., the box was mounted on a metallic rod that slid along a metallic track; the box's movements were thus correlated with a soft but noticeable metallic noise). To test this hypothesis, an additional group of 9.5-month-old infants was tested with static test displays from which all inadvertent clues had been removed. In the possible display, the infants saw a box resting fully on a platform; in the impossible display, only one corner of the box was in contact with the platform. The infants looked reliably longer at the impossible than at the possible display, suggesting that they were surprised (at long last!) that the box did not fall when supported only at its corner by the platform.

What is being proposed is that, like the 9.5-month-old infants in Baillargeon's (1992b) initial experiment, the 6-month-old infants in the experiment of Spelke et

[2]A point that may be relevant is that in the experiment (described earlier) in which Spelke et al. (1992b) found evidence of sensitivity to support in 6-month-old infants (Expt. 1), the ball with the concealed wooden rod was used only in the final portion of the test events and was never moved before the infants. This contrasts with the experiment under discussion (Spelke et al., 1992b, Expt. 3), in which the ball with the concealed rod was used throughout the habituation and test events and was repeatedly moved before the infants.

al. (1992b, Expt. 3) may have failed to show a preference for the impossible event, not because their understanding of support was lacking, but because some aspect of the habituation or test events clued them to the presence of the concealed rod. Further research is needed to evaluate this possibility.

## 6. CONCLUDING REMARKS

The results discussed in the previous section suggest two conclusions. The first is that young infants *do* possess intuitions about objects' support and expect objects to fall when their supports are removed. The second conclusion is that *whether* infants reveal their knowledge of support in a particular experimental situation appears to depend on several factors, including (a) whether infants are presented with static or dynamic support violations (4.5-month-old infants appear to be successful only with the latter, whereas 6-month-old infants can reason about either); (b) whether infants are focusing on the relevant aspects of the events; and (c) whether infants are able to use inadvertent clues to infer hidden means of support. No one ever said that research on infants' physical reasoning would be easy – just lots of fun!

What are the theoretical implications of the finding that 4.5- and even 3-month-old infants (Needham & Baillargeon, 1992) possess intuitions about support relations between objects? Should the presence of such knowledge at such a young age be taken to suggest that infants are born with fundamental intuitions about support that are progressively enriched over time? We think not. Our position is that infants are born, not with substantive beliefs about objects, but rather with highly constrained learning mechanisms that enable them to quickly arrive at important generalizations about objects. Because the same mechanisms underlie infants' acquisition, at different ages, of knowledge about different physical phenomena (e.g., occlusion, support, collision phenomena), important parallels can be seen, across ages and phenomena, in the development of infants' reasoning. For a detailed description of these parallels, the reader is referred to Baillargeon (1992a, in press-a, in press-b). For the present, only one tenet of our model of the development of infants' physical reasoning will be mentioned. According to this tenet, when learning about a new physical phenomenon, infants first identify an *initial concept* that captures the essence of the phenomenon but few of its details. With experience, this preliminary, all-or-none concept is progressively elaborated. Infants come to identify *variables* that are relevant to the phenomenon, study their effects, and incorporate this accrued knowledge into their reasoning, resulting in increasingly accurate predictions over time.

The present results, together with those of Baillargeon et al. (1992), fit very well within such a description. Recall that the 6.5-month-old infants tested by

Baillargeon et al. were surprised that a box remained stable when pushed until only its corner remained on a platform, but the 5.5-month-old infants were not. These findings suggest the following developmental sequence. By 4.5 months of age, infants expect a box to fall when it loses all contact with a supporting platform, and to remain stable otherwise. At this stage, *any* amount of contact between the box and the platform is deemed sufficient to ensure the box's stability. By 6.5 months of age, however, infants recognize that a box can fall even when partially supported, and that the *amount of contact* between the box and the platform can be used to predict whether the box will be stable. One way of stating these results is that infants' initial concept focuses on the presence versus the absence of contact between objects and their supports; to this initial concept is later added a variable having to do with the amount of contact between objects and their supports.

What experiences might contribute to the development of infants' knowledge about support? Consider the initial concept "objects fall when they lose contact with their supports". As was mentioned earlier, even very young infants have multiple observations and manipulations consistent with this notion. Thus, infants may note that their pacifiers fall when they open their mouths, and that toys fall when they open their hands. Similarly, infants no doubt have numerous opportunities to observe their parents and siblings drop objects: toys in baskets, cheerios in bowls, peas in pots, pens in briefcases, clothes in hampers, and so on. It is not implausible that, from these repeated experiences, infants learn that objects typically fall when they lose contact with their supports.

What further experiences might lead infants, at about 6.5 months of age, to realize that "the amount of contact between an object and its support can be used to predict whether the object will be stable"? One hypothesis is that this development reflects advances in infants' manipulations of objects. Researchers have reported that it is at 5–6 months of age that most infants learn to sit with support or, to use Rochat's (1991) terminology, become "self-sitters". It may be that, as infants become "self-sitters", they are more likely to be seated in high-chairs, walkers, or sassy-seats in front of tables or trays. For the first time, infants may have the opportunity to deposit objects on surfaces and to note that objects tend to fall unless a significant portion of their bottom surfaces is supported: bottles, cups, and toys placed on the edges of tables typically fall to the ground.

These speculations suggest that infants less than 6.5 months of age *could* learn that the amount of contact between an object and its support matters, if provided with appropriate data (we assume that infants rarely see their caretakers deposit objects on edges and so have little data from which to abstract this variable until they do the deed themselves). We are planning to test this prediction through teaching experiments in which infants less than 6.5 months of age will be shown that (symmetrical) objects typically fall when too small a portion of their bottom

surfaces rests on a supporting surface. Beyond leading us to a fuller understanding of the developments of infants' intuitions about support, these experiments should also shed light on the nature of the learning mechanisms that guide infants' acquisition of physical knowledge. By discovering precisely what observations, and how many observations, are necessary for infants to learn about a specific variable, we hope to come one step closer to understanding the fundamental properties of infants' approach to learning about the physical world.

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