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Is it a Container? Young Infants' Understanding of Containment Events

Yi Mou
University of Illinois

Yuyan Luo
University of Missouri

The present research examined how certain features of a box affected 4.5-month-old infants' interpretation of containment events the box was involved in. If the box was a regular container, infants did not respond with increased attention when a tall cylinder became fully hidden after being lowered inside the box, consistent with previous research. In contrast, if a three-sided object (the box without its back) replaced the box, or if shown that the box had a removable back, infants were able to detect the height violations, 3 months earlier than they normally would. These results demonstrate how infants' perception or representation of objects interplays with their interpretation of physical events these objects involve in.

Over the past 30 years or so, studies on infants' understanding about physical objects and events show that infants attend to the object category involved in physical events (e.g., a container, cover, or tube) and interpret and predict the outcomes of these events accordingly (for reviews, see Baillargeon, 2002; Baillargeon, Li, Ng, & Yuan, 2009). For example, infants seem to differentiate between occlusion (i.e., one object behind another) and containment (i.e., one object inside a container) events based on spatiotemporal relations between the objects involved in the events and learn to reason about these events separately (Aguiar & Baillargeon, 1999; Hespos & Baillargeon, 2001a,b, 2006). In a looking-time violation-of-expectation task, 4.5-month-olds responded with heightened interest when a tall object became fully hidden *behind* a shorter occluder or a container (i.e., a height violation) but not when the same tall object was fully hidden *inside* the container (Hespos & Baillargeon, 2001a). It was not until infants were 7.5 months when they responded with increased attention to the physically impossible event involving the container. Possible reasons for the décalage have been discussed elsewhere (the explanation-based learning account; Baillargeon

Correspondence should be sent to Yi Mou, Psychology Department, University of Illinois, Champaign, IL 61820. E-mail: yimou@illinois.edu and Yuyan Luo, Department of Psychological Sciences, University of Missouri, Columbia, MO 65211. E-mail: luoy@missouri.edu

et al., 2009; DeJong, 1993; Hespos & Baillargeon, 2001a; Wang & Baillargeon, 2008). For instance, everyday observations and object manipulations may contribute to the realization that taller but not shorter objects remain partially hidden behind occluders. Such exposure involving containers, however, is perhaps more sparse. Infants therefore need several more months to come to the realization that taller objects should also remain partially hidden inside containers. Nevertheless, these results suggest how infants appear to partition the physical world in meaningful ways to facilitate learning. Interestingly, adults' detection of changes in an object's height is also affected by whether the object is involved in an occlusion or a containment event, suggesting a developmental link of such event categorization (Strickland & Scholl, 2015).

How does infants' object knowledge interplay with their event categorization? The objects used in the research described above are prototypical containers, covers (i.e., containers turned upside down), or tubes (i.e., containers with bottoms removed). Do infants have any understanding about these object concepts? Take containers as the example. Adults may focus on functional properties and articulate that containers should have four sides and a bottom to store and transport objects or substances (Kelemen & Carey, 2007). How do we examine preverbal infants' perceptions or representations of containers? One way to address these questions is to compare infants' responses to the same physical events involving prototypical versus atypical objects differing in certain functional properties. This is analogous to a previous study showing that infants responded differently to physical events involving objects of different ontological kinds (Luo, Kaufman, & Baillargeon, 2009). For example, 6-month-old infants responded with heightened interest when an inert object but not a self-propelled object remained stationary after being hit by a hand.

In the present research, we addressed how young infants would react to a height violation containment event involving an atypical or a dysfunctional container. We used a container, that is, a box, and created a three-sided object by removing its back. In Experiment 1, 4.5-month-olds saw height violation events involving the box or the three-sided object. The two objects differed in their functional properties. The three-sided object, missing its back, could no longer store or transport noncohesive substances. In Experiment 2, we showed infants how the back of the box could be removed to create the three-sided object. Infants then watched the same height violation events involving the box with the removable back. If infants' perception or representation of the box affected how they interpreted the containment event, we might find evidence of height violation with the three-sided object because it was a dysfunctional container, or even with the box with the removable back because it had the potential to become the three-sided object and hence dysfunctional. These results would thus demonstrate for the first time that infants' perception or representation of an atypical or a dysfunctional object also affects how they interpret physical events the object is involved in. This would in turn inform us on infants' understanding of concepts such as containers. We will return to this issue in the General Discussion section.

EXPERIMENT 1

In this experiment, 4.5-month-old infants were randomly assigned to a box or a three-sided object condition modeled after Hespos and Baillargeon (2001a). In the box condition (see Figure 1), infants first received familiarization trials in which they saw a tall

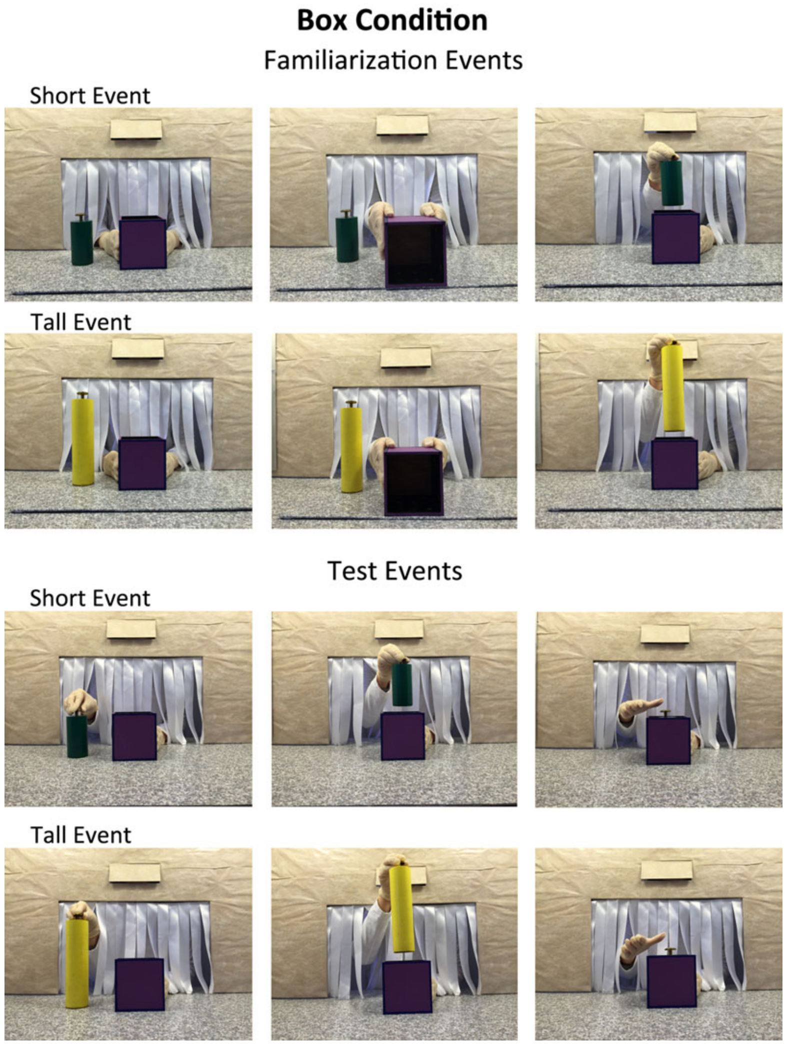

Figure 1 Photographs of the events shown in the familiarization and the test trials of the box condition in Experiment 1.

(tall event) or a short (short event) cylinder stand next to the box. An experimenter rotated the box forward 90 degrees so that infants could clearly see its inside and bottom and then rotated it back. Next, the experimenter lifted the cylinder, moved it over and above the box and then returned it to its original position. The event cycle repeated until the trial ended. During the test trials, after each cylinder was moved above the box, it was lowered into the box and became fully hidden. This event outcome was physically possible because the short cylinder was shorter than the box (short event) but physically impossible with the tall cylinder because it should have protruded above the box (tall event). Because infants younger than 7.5 months should be unable to detect the height violation when a container is involved, we predicted that infants in the box condition should look about equally at the short and tall test events.

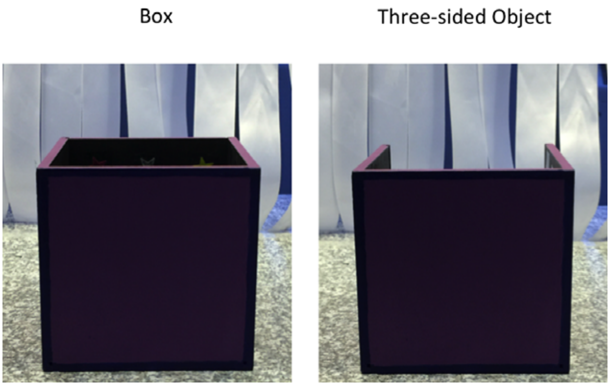

Figure 2 The box and the three-sided object used in Experiment 1.

Infants in the three-sided object condition received similar familiarization and test trials except that the three-sided object replaced the box (see Figure 2). If infants did not view the three-sided object as a regular container, because it could not contain noncohesive substances as a typical container does, they might be able to detect height violations when it was used. Infants in the three-sided object condition would thus look reliably longer at the tall than at the short event during test.

Method

Participants

Participants were 32 healthy term infants (17 male, $M = 4$ months, 23 days, range: 4 months, 4 days to 5 months, 29 days). Half of the infants (nine male, $M = 4$ months, 23 days) were randomly assigned to the box condition, and the rest to the three-sided object condition. Three infants were tested but excluded for fussiness ($n = 2$) or observer error ($n = 1$). The infants' names were obtained from commercial mailing lists or a university listserv. Parents were contacted by letters, emails, and follow-up phone calls; they were offered reimbursement for their travel expenses. Of the 48 infants in this and the following experiments, 94% were non-Hispanic, 4% were Hispanic, and 2% did not answer. Of the non-Hispanic sample, 91% were white, 2% Asian, and 7% multiracial.

Apparatus

The apparatus was a wooden display stage (114 cm high × 104 cm wide × 47.5 cm deep) resting on a platform 76 cm above the ground. The stage had a front opening (53 cm high x 102 cm wide) with a white curtain (61 cm high x 104 cm wide) hung up in front of the opening that could be lowered down between trials. The floor and the back wall of the apparatus were made of foam board, and they were covered with gray and beige granite-patterned contact paper, respectively. There was a rectangular window (31 cm high x 53.5 cm wide) in the midsection of the back wall, and it was covered with white fringe. An experimenter, wearing a white shirt and rubber gloves, sat behind the rectangular window and used the window to manipulate objects.

A rectangular peephole (18 cm wide × 7 cm high) was 6 cm above the window. The experimenter could watch her actions on the objects through the peephole. A flap on the peephole prevented infants from seeing the experimenter's eyes or face.

The objects used in this experiment were two cylinders made of plastic pipes and a box with removable back and bottom (when the back was removed, it became the three-sided object). The short cylinder was covered with green tape, 11.2 cm high and 6 cm in diameter. The tall cylinder was similar except that it was 22.2 cm high and covered with yellow tape. Both cylinders had a metal knob (2 cm in height) centered on the top. The box (12 cm wide × 12 cm high × 12 cm deep) consisted of Plexiglas pieces glued together, each 0.6 cm thick. The outside of the box was painted purple and the edges highlighted in blue, making the frame of the box salient. The inside of the box's four sides was painted black and decorated with 9 colorful stickers on each side (3 columns × 3 rows). The inside of the box's bottom was covered with wood-patterned contact paper to highlight the difference between the bottom and the sides. The back of the box could be slid in and out along slits cut on the adjoining sides. The box was used in the box condition. It was used in the three-sided object condition with its back removed.

In the tall test events of both conditions, the bottom of the box or the three-sided object was removed (for the experimenter's convenience, we used a tube, identical to the box but without a bottom, in the tall test events for eight infants in the box condition and six in Experiment 2, instead of the box with its bottom removed). The tall cylinder could thus be lowered through a hidden square hole (10 cm × 10 cm) in the apparatus floor and rested on a platform underneath. Both the tall and the short cylinders were fully hidden after being lowered inside the box or the three-sided object with only the knob showing. The hole in the floor was uncovered during the test trials but stoppered during the familiarization trials by a rectangular piece of foam board (31 cm high × 53.5 cm wide) covered with gray granite-patterned contact paper, same as the apparatus floor.

During this experiment, two camcorders were used. One was used to record the events being shown on the apparatus, and the other to record infants' looking behavior. The images from the two camcorders were combined into a single video frame that allowed both online monitoring and offline data checks.

Procedure

The infant sat on a parent's lap in front of the apparatus. Before the experiment began, the experimenter showed the infant the two cylinders and the box or the three-sided object one by one. Parents were instructed to close their eyes during the test trials and not interact with the infant. Infants in both conditions received four familiarization trials and six test trials alternating between the short and the tall events. Seven of the 16 infants in each condition saw the tall event first in both the familiarization and the test trials, and the remainder saw the short event first. A metronome that beat softly once per second was used to help the experimenter adhere to the scripts.

The box condition. Familiarization events. *Short event*: To start, the experimenter held the box with both hands, and the short cylinder stood on the box's left (see Figure 1). Infants watched the scene for 2 cumulative seconds, and then, the actions began. After a 1-sec pause, the experimenter rotated the box 90 degrees toward the infant (1 sec) (the numbers in parentheses indicate the time to conduct that action) so that the infant could see the inside and the bottom of the box. After 2 sec, she rotated it back (1 sec) and paused for 1 sec. Next, she grasped the cylinder by the knob with her right hand (1 sec), lifted it (1 sec), and moved it horizontally until it was right above the box (1 sec). After a 1-sec pause, she moved the cylinder back to the left (1 sec), put it down in its initial location (1 sec), and moved her right hand back on the box (1 sec). The 13-sec event cycle repeated until the trial ended. Each familiarization trial ended when the infant looked away for 2 consecutive seconds after having looked at it for at least 13 cumulative seconds or looked for 60 cumulative seconds without looking away for 2 consecutive seconds. *Tall event:* This event was identical except that the tall cylinder was used.

Test events. *Short event*: To start, the experimenter held the box with her left hand and the knob of the short cylinder with her right hand (see Figure 1). Infants watched the scene for 2 cumulative seconds, and then, the actions began. After a 1-sec pause, the experimenter lifted the cylinder (2 sec), moved it above the box (1 sec), and lowered it into the box (3 sec). She then moved her hand about 5 cm away from the cylinder (1 sec) and paused for 1 sec so that it was clear that the cylinder was fully hidden inside the box with only the knob showing. Next, the experimenter grasped the cylinder (1 sec), lifted it (2 sec), moved it to the left (1 sec), and put it down in its initial location (3 sec). She moved her hand about 5 cm away from the cylinder (1 sec) and paused (1 sec). The 18-sec event cycle repeated until the trial ended. Each test trial ended when the infant looked away for 2 consecutive seconds after having looked at it for at least 9 cumulative seconds, or looked for 60 cumulative seconds without looking away for 2 consecutive seconds. *Tall event:* This event was identical except that the tall cylinder was used.

The three-sided object condition. This condition was similar to the box condition except that the three-sided object was used.

Seven of the 32 infants contributed data from the first pair ($n = 2$) or the first two pairs ($n = 5$) of the six test trials because of fussiness ($n = 3$), experimenter errors ($n = 2$), or observer errors ($n = 2$). For these infants, the last two or the last one test pairs were treated as missing data.

Of the 48 infants in the two experiments, 43 were tested with experimenters who were blind to the hypotheses regarding each condition. All experimenters were required to follow the scripts designed to ensure that the events were presented similarly to each infant. Two naïve observers sat behind large white cloth-covered frames on either side of the apparatus and observed infants through peepholes in the frames. When the infant looked at the event, the observers pressed a button on a controller linked to a computer software (Baillargeon & Barrett, 2005). The primary observer's looking times were used to determine the endings of the trials. Interobserver agreement was measured for 43 of the 48 infants in the two experiments because only the primary observer was present for five infants and averaged 92% per trial per infant.

Preliminary analyses of test data revealed no significant interactions between condition and event with sex and/or order, all $Fs(1, 24) < .90$, $ps > .250$; the data were therefore collapsed across sex and order in subsequent analyses.

RESULTS

The analysis of infants' *familiarization* looking times (see Figure 3) with SAS software revealed that infants in the two conditions did not look for significantly different lengths of time at the two types of events, $F(1, 30) = 2.12$, $p = .156$, $\eta^2_{partial} = .066$ (box condition: tall event: $M = 46.2$, $SD = 13.0$; short event: $M = 46.8$, $SD = 13.3$; three-sided object condition: tall event: $M = 50.8$, $SD = 11.4$; short event: $M = 45.8$, $SD = 15.0$).

Infants' looking times in the *test* trials (see Figure 3) were averaged and analyzed using a 2 × 2 repeated-measures analysis of variance (ANOVA) with condition (box or three-sided object) as a between-subjects factor and event (tall or short) as a within-subject factor. The analysis yielded a significant Condition × Event interaction, $F(1, 30) = 5.77$, $p = .023$, $\eta^2_{partial} = .161$. No other effect was significant. Planned comparisons revealed that infants in the three-sided object condition looked reliably longer at the tall ($M = 31.0$, $SD = 14.4$) than at the short event ($M = 25.9$, $SD = 14.0$), $F(1, 30) = 5.33$, $p = .028$, Cohen's $d = .582$, while those in the box condition looked about equally at the tall ($M = 22.9$, $SD = 11.2$) and the short ($M = 25.3$, $SD = 15.3$) events, $F(1, 30) = 1.19$, $p > .250$, $d = -.288$. Examinations of individual infants' looking times confirmed these results. Eleven of the 16 infants in the three-sided object condition looked longer at the tall than at the short event, Wilcoxon signed-ranks $z = 2.02$, $p = .044$, whereas only six of the 16 infants in the box condition did so, $z = 1.03$, $p > .250$).

DISCUSSION

The null results of the box condition were consistent with previous findings that infants younger than 7.5 months failed to detect height violations in containment events (Hespos & Baillargeon, 2001a, 2006). By contrast, the positive results of the three-sided object condition suggested that 4.5-month-old infants did not view the

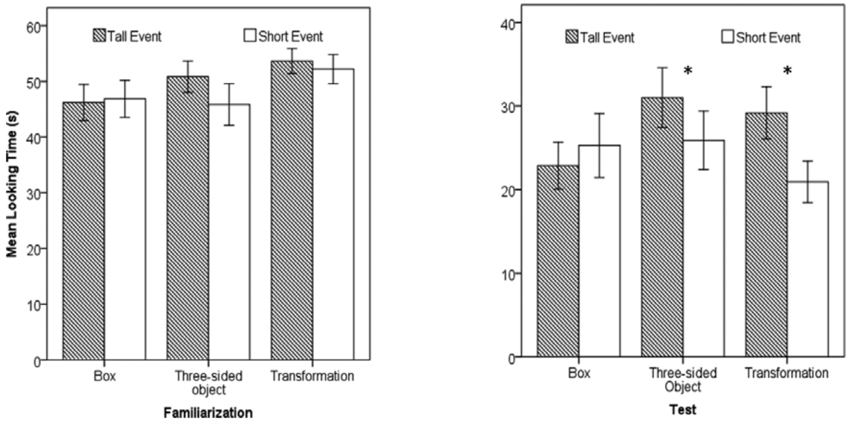

Figure 3 Infants' mean looking time during the familiarization and test trials in the box and the three-sided object conditions of Experiment 1 and the transformation condition of Experiment 2. Results are shown as a function of event type and condition. Error bars represent standard errors. An asterisk denotes a significant difference between events ($p < .05$).

three-sided object as a container. Otherwise, they would have responded as did those in the box condition.

Previous results have shown that infants at 3.5–4.5 months of age can detect height violations in occlusion events (Baillargeon & DeVos, 1991; Hespos & Baillargeon, 2001a). Could the 4.5-month-old infants in the three-sided object condition have construed the test event as an occlusion? It remained unclear. On the one hand, the front side of the object did hide the cylinders, as occlusion is an inherent part of any containment event. On the other hand, the three-sided object condition was very similar to the box condition in the following aspects. The familiarization and test trials ensured that infants could clearly see that the cylinder was lowered inside the three-sided object, but not behind it. Additionally, the cylinder's knob being visible above the object when it was inside served as a reminder of the spatial relationship between the two. Therefore, in Experiment 2, we again used the box to present containment events to infants. We examined whether an additional feature of the box, that is, having a removable back, would affect infants' perception of the box as a regular container because it had the potential to become dysfunctional as the three-sided object. This would in turn affect infants' detection of height violations.

EXPERIMENT 2

This experiment was identical to the box condition of Experiment 1 except that two transformation trials were inserted between the familiarization and the test trials. In the transformation trials (see Figure 4), the experimenter showed how the box

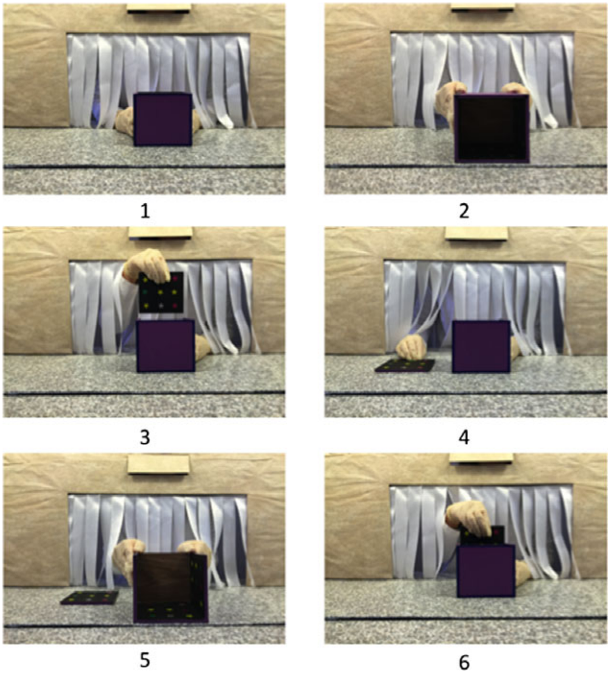

Figure 4 Photographs of the event shown in the transformation trials of Experiment 2.

transformed into the three-sided object; she rotated the box forward so that infants could see its bottom and inside and then rotated it back, slid out its back and set it aside, rotated the three-sided object forward and then back, and finally put the back piece in place so that it was the box again. The event cycle repeated until the trial ended. The test trials still depicted containment events because it was the box that was used, which should have resulted in null results as in the box condition of Experiment 1. The transformation trials, however, made clear that the box was no regular container—it had a removable back and hence the potential to become dysfunctional as the three-sided object. If infants were sensitive to this additional feature of the box, they might be less likely to view it as a container. If so, infants might again be able to detect height violations in the test trials and respond as did those in the three-sided object condition of Experiment 1.

Support for this hypothesis comes from previous results showing that the fission of solid objects impaired infants' object representation. For example, 8-month-olds failed to detect the disappearance of a pile of blocks after seeing it being decomposed into individual blocks and rearranged into a pile by a hand, unless they had handled the pile beforehand (Chiang & Wynn, 2000). Furthermore, 10- to 12-month-olds failed to represent quantities after witnessing a fission event (Cheries, Mitroff, Wynn, & Scholl, 2008). They saw two crackers being lowered into a cup and one cracker into another cup and then crawled to the one with a greater amount. These results did not hold, however, if a big cracker was split into two even halves and lowered into the cup, although the quantities to compare were kept identical in the two conditions. In the current transformation event, the box also went through a fission: Its back was slid in and out. We therefore predicted that the fission would affect infants' perception or representation of the box.

Method

Participants

Participants were 16 healthy term infants (seven male, $M = 4$ months, 21 days, range: 4 months, 4 days to 5 months, 25 days). Four infants were tested but excluded for drowsiness ($n = 1$), observer error ($n = 1$), a long feeding break ($n = 1$), or looking-time difference at test more than 2 *SD* from the mean of the condition ($n = 1$).

Apparatus and procedure

The apparatus and procedure of Experiment 2 were similar to those of the box condition in Experiment 1 except that two transformation trials were inserted between the familiarization and the test trials. At the beginning of the transformation trial, the experimenter held the box with both hands; no cylinder was present. After infants watched the scene for 2 cumulative seconds, the actions began. After a 1-sec pause, the experimenter rotated the box 90 degrees forward (1 sec), paused (2 sec), and rotated it back (1 sec). Next, she grasped the back of the box with her right hand (1 sec), pulled it out (1 sec), moved it to the left (1 sec), and put it down on the apparatus floor (2 sec). She then held the three-sided object with both hands (1 sec). After a 1-sec pause, she rotated it 90 degrees toward the infant (1 sec), paused (2 sec), and rotated it back (1 sec). She then grasped the back on the floor (1 sec), lifted it (1 sec), moved it above the object (1 sec), and slid it down along the slits (2 sec) to make the object whole again. Finally, she held the box with both hands (1 sec). The 22-sec event cycle repeated until the trial ended. Each transformation trial ended when the infant looked away for 2 consecutive seconds after having looked at it for at least 11 cumulative seconds, or looked for 60 cumulative seconds without looking away for 2 consecutive seconds.

Seven of the 16 infants in Experiment 2 saw the tall event first in both the familiarization and the test trials, and the remainder saw the short event first. Five of the 16 infants contributed data from the first pair ($n = 3$) or the first two pairs ($n = 2$) of test trials because of fussiness ($n = 2$) or experimenter errors ($n = 3$). For these infants, the last two or the last one test pairs were treated as missing data.

During the two transformation trials, infants looked on average for 43.0 sec ($SD = 18.0$). Preliminary analyses of test data revealed no significant interactions among event and sex and/or order, all Fs(1, 12) < 1.45, ps > .250; the data were therefore collapsed across sex and order in subsequent analyses.

RESULTS

The analysis of infants' *familiarization* looking times (see Figure 3) revealed that there was no significant difference involving event, $F(1, 15) = .23$, $p > .250$, $\eta^2_{partial} = .015$ (tall event: $M = 53.6$, $SD = 8.9$; short event: $M = 52.2$, $SD = 10.5$).

Infants' looking times in the *test* trials (see Figure 3) were averaged and analyzed using a single-factor ANOVA with event (tall or short) as a within-subject factor. The analysis revealed that infants looked reliably longer at the tall ($M = 29.2$, $SD = 12.5$) than at the short event ($M = 20.9$, $SD = 9.9$), $F(1, 15) = 7.63$, $p = .015$, $\eta^2_{partial} = .337$, Cohen's $d = .713$. Examinations of individual infants' looking times confirmed these results; 12 of the 16 infants looked longer at the tall than at the short test event, Wilcoxon signed-ranks $z = 2.22$, $p = .026$.[1]

Analyses of data in experiments 1 and 2

The analysis of infants' *familiarization* looking times revealed that infants in the three conditions did not look for significantly different lengths of time at the two types of events, $F(2, 45) = 1.01$, $p > .250$, $\eta^2_{partial} = .043$. The analysis of infants' *test* looking times, on the other hand, yielded a significant effect of Event, $F(1, 45) = 6.40$, $p = .015$, $\eta^2_{partial} = .125$, and a significant Condition × Event interaction, $F(2, 45) = 4.81$, $p = .013$, $\eta^2_{partial} = .176$. Planned comparisons confirmed that (1) infants in

[1]We also tested 13 infants with a procedure similar to that of Experiment 2 except that the order in the event cycle during the two transformation trials was reversed: the experimenter started by holding the three-sided object while the back piece rested on the apparatus floor; she put the back in to make the box whole. Event cycles repeated until the trial ended. As in Experiment 2, the two transformation trials were inserted between the familiarization and the test trials. During the test trials, infants looked about equally at the tall and the short events. We had intended this to be an ineffective transformation so that infants would still view the box as a container and fail to detect the height violation during the test trials. We realized, however, that this was a less than optimal design. Infants could simply have been confused when the transformation trials started with the three-sided object while the box was used in both the familiarization and the test trials, leading to null results.

the box condition looked about equally at the tall and short test events, $F(1, 45) = .93$, $p > .250$, (2) infants in the three-sided object condition looked reliably longer at the tall than at the short event, $F(1, 45) = 4.18$, $p = .047$, and (3) those in the transformation condition of Experiment 2 also looked reliably longer at the tall than at the short event, $F(1, 45) = 10.91$, $p = .002$.

Although the differences were not reliable, there was a tendency for infants in the three-sided object condition of Experiment 1 and those in the transformation condition of Experiment 2 to look longer at the tall than at the short event during the familiarization trials. The test data of the three conditions were therefore subjected to an analysis of covariance (ANCOVA); the factors were the same as in the ANOVA, and the covariates were infants' mean looking times at the tall and the short events during the familiarization trials. The results replicated those of the ANOVA: the Condition × Event interaction was significant, $F(2, 43) = 4.53$, $p = .016$, $\eta^2_{\text{partial}} = .174$. Planned comparisons confirmed that infants in the box condition looked about equally at the two test events, $F(1, 43) = .89$, $p > .250$, whereas those in the three-sided object ($F(1, 43) = 3.48$, $p = .069$) and the transformation ($F(1, 43) = 11.72$, $p = .001$) conditions still looked longer at the tall than at the short test event.

DISCUSSION

Infants in Experiment 2 responded with prolonged looking when the tall cylinder became fully hidden inside the box. These positive results were in stark contrast to the negative results of the box condition of Experiment 1. The only difference between the two conditions was the back of the box being shown to be removable so that the box could be transformed into a three-sided object, prior to the test trials. This property alone appeared to change how infants viewed the box and enable them to detect the height violation during the test trials, which they normally would not have been able to do. Future research will explore whether or not placing the transformation trials before the familiarization trials could yield positive results as well. This can help pinpoint the time frame of the transformation's effect on infants' representations of the box.

Note that in the transformation trials, the back of the box was slid in and out along slits on the sides, in a manner akin to a screw cap of a bottle. To our knowledge, this was the first infant study to feature such a property in an object. How might the transformation in the present experiment have affected infants' representation of the box? There are at least two possibilities. One is that as in previous studies described above (e.g., Cheries et al., 2008), the transformation might have disrupted infants' representation of the box. This disruption, however, led to positive results: Infants detected height violations during the test trials when the box was used. Another possibility is that because the transformation the box went through was not as abrupt as a cracker being split into two halves (Cheries et al., 2008), since only one part of the box came off and it did so slowly and gradually, the representation of the box was kept somewhat intact (i.e., it was an atypical container) (Cacchione & Call, 2010) and hence facilitated infants' detection of height violations during the test trials.

Intuitively, adults may respond differently from infants to similar fission events. A big cracker broken into two even halves still has the same amount of food. Or, a box with a removable back can still be used to store and transport objects or substances.

Future research can examine how infants' object representations can become sufficiently robust over time to withstand transformations or fissions.

GENERAL DISCUSSION

The present research examined how 4.5-month-old infants used their perception or representation of a box to make sense of containment events the box was involved in. If the box was a regular container, as in previous research (Hespos & Baillargeon, 2001a, 2006), infants did not respond with increased attention when a tall cylinder became fully hidden after being lowered inside the box. In contrast, if a three-sided object (the box without its back) replaced the box, or if shown that the box had a removable back, infants were able to detect such height violations.

Therefore, when the box was missing its back or even had a removable back, 4.5-month-olds did not seem to treat it as a regular container—they detected violations when a taller cylinder became fully hidden inside it, 3 months earlier than they normally would. How did they do so? Baillargeon and colleagues (Baillargeon, Li, Gertner, & Wu, 2011; Baillargeon et al., 2012) propose that infants seem to be born with a physical reasoning (PR) system, a causal explanatory framework, which is activated as a physical event unfolds and enables infants to interpret and predict the event outcome in accordance with core principles such as the principle of persistence (e.g., the tall cylinder persisted as it was through time and space and hence should have protruded above the box). The PR system has two layers, structural and variable. The *structural* layer includes spatiotemporal (e.g., the cylinder was lowered inside the box) and categorical information about objects involved in an event (e.g., the cylinder and the box were inert objects; and critically whether or not the box was a container). The *variable* layer includes variable information infants have learned about the event. In the tall test event of the box condition of Experiment 1, for example, infants would categorize the event as a containment and hence not include height information in their representation because they usually identify height as a containment variable at about 7.5 months. As a result, their PR system would not detect the violation when the tall cylinder was fully hidden inside the box. Infants would keep information such as heights and widths in their representations of the objects. In this case, however, their PR system would not access height information from object representations. There have been successful manipulations that "tricked" the PR system to use height information, suggesting its flexibility (Wang & Baillargeon, 2005). For example, when a tall object and a short container involved in an occlusion (the object was moved in front of the container) and then a containment event (the object was lowered inside the container) (Wang, 2011). The height information was retained in the PR system from the occlusion event; 4.5-month-olds then detected the height violation in the containment event when the tall object failed to protrude above the container.

In the present three-sided object and the transformation conditions, the PR system perhaps would *not* categorize the test events as containment events because the categorical information would *not* flag the three-sided object as a container or the box with the removable back as a regular container. The fact that infants were able to detect height violations suggested that the PR system had somehow accessed height information about the objects. One possibility is that the PR system had treated the event as an occlusion event, even though it was truly a containment event in the transformation condition and very much so in the three-sided object condition. If so, younger infants such as 2.5-month-olds, who do not yet identify height as a variable in occlusion or containment events, would fail to detect height violations in the present task. Another possibility is that the PR system would access all object information by default even if the unfolding physical event was ambiguous. If so, even 2.5-month-olds would succeed in detecting height violations in the present task. Alternatively, given the flexibility of the PR system, it might access height information simply because it was triggered by the three-sided object with its open back or the box with the removable back.[2] One way to test this is to strengthen the container status of the objects during the test trials, for example, by calling infants' attention to the upper edges of the box with the removable back. If 4.5-month-old infants failed to detect height violations, it would have in turn bolstered our claim that infants' perception or representation of the objects as containers determined their responses to the height violation containment events. Future research will explore these possibilities.

Why did the 4.5-month-old infants *not* view the three-sided object and the box with a removable back as regular containers, leading to their success in detection of height violations? The three-sided object only differed from the box in its missing a back. Would young infants have such understanding that containers should have a bottom and all sides? If so, would a box with a narrow opening in its back not be viewed as a container? As mentioned in the Introduction, adults' concepts of containers as tools include understanding about their functional properties. Containers are designed to store and transport objects or substances; they therefore have a bottom and closed sides to create an enclosed space to fulfill this intended function (Kelemen & Carey, 2007). The three-sided object is not a container because it is dysfunctional: it cannot contain substances. The positive results of Experiment 1 suggest that young infants might be sensitive to containers' functional properties as well. In addition, intended function is weighted substantially in adults' kind judgments: an artifact that is used for watering flowers but made for brewing tea is still a "teapot." (Hall, D. G., unpublished data; Matan & Carey, 2001) Or, a broken coffee pot is still a coffee pot, but the coffee pot becomes a bird feeder after it undergoes elaborate transformations to be made into one (Keil, 1989). Like adults, preschoolers rely on artifacts' intended function in kind judgments. When faced with familiar but dysfunctional objects, 2-year-olds were more likely to apply the category label (e.g., "cup") to damaged ones (e.g., a broken cup) than the intentionally dysfunctional ones (e.g., a cup with a hole created in the bottom) (Kemler Nelson, Holt, & Egan, 2004). Would infants' understanding of containers also include intentional functional properties? Therefore, because the box with a removable back had the potential to become dysfunctional, was it designed to be so and hence not a typical container? How would infants treat a container that became dysfunctional by accident? Addressing these questions will shed light on how infants come to construe containers as tools or artifacts. The present research, by examining infants' interpretation of physical events involving atypical or dysfunctional containers, provides a novel approach to exploring young infants' conceptual knowledge.

[2]We thank an anonymous reviewer for suggesting this alternative.

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