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Perception of Dynamic Object Relations in Infancy

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Depending upon the translations imposed upon objects, the properties of these objects may have different consequences for the outcome of an interaction. A translation that imposes constraints upon the outcome of most mechanical interactions is the direction of approach of an object towards another object. Slight variations in approach may lead to totally different interactions between the same objects. We investigated 6-, 9-, and 12-month-old infants' ability to perceive the constraints of different directions of approach upon the outcome of an interaction between a block and a box. A violation of expectancy paradigm was used. If infants perceive which outcome is constrained by the approach, longer looking times would be expected for an outcome that violates this perception than for an outcome that confirms it. This prediction was supported with 12-month-old infants in two cases. In the first case, a block approached the opening and a rim of a box and penetrated the opening of the box apparently through its rim. In the second case a block approached one rim of a box and became supported by this rim even though support was insufficient. The findings were discussed in terms of infants' sensitivity to optical information.

infant perception object interactions optical information dynamic object relations

Recent research on object perception in infancy reveals the early presence of fundamental insights in mechanical interactions between objects. More specifically, the results show a rapid growth in infants' understanding of the way in which motion principles (Baillargeon, 1987a; Spelke, Breinlinger, Macomber, & Jacobson, 1992; Spelke, Simmons, Breinlinger, Jacobson, Keller, & Macomber, personal communication) and relations between object properties (Baillargeon, 1987b; Baillargeon, Needham, DeVos, 1992; Keil, 1979; Needham & Baillargeon, 1993; Sitskoorn & Smitsman, 1995) constrain the course and outcome of interactions between objects.

Studies on infants' insight into interactions have been mostly directed towards infants' perception of object properties and how these object properties constrain the outcome of an interaction. However, depending upon the translation imposed upon objects, the properties of these objects may have different consequences for the outcome of the interaction. For example, a block that is smaller than the opening of a box can potentially pass through this opening. However, whether it will indeed pass through the opening or will collide with the rims of the box depends also upon the block's path of approach towards the box. The present study investigates infants' perception of the constraints of a translation upon the outcome of an interaction.

Theories of infant perception of objects and their interactions take translations directly or indirectly into account. According to Spelke's central origin thesis (Spelke, 1994; Spelke et al., 1992), infants are endowed with core knowledge about object motion principles. This enables them to represent objects, to reason about them, and to gain insight into object interactions. The core knowledge is in accordance with four basic principles: continuity (objects move only on connected paths), solidity (objects move only on unobstructed paths), gravity (objects move downward in the absence of support), and inertia (objects do not change their motion abruptly and spontaneously). Cognitive development involves an enrichment around constant core principles. From a series of experiments (Spelke et al., 1992) it was concluded that infants are indeed able to represent and reason about objects and their interactions in a way that accords with certain motion principles.

Sitskoorn and Smitsman (1995) favor a different view on infants' perception of object interactions. When objects interact, relations between the properties of these interacting objects emerge. Which relations emerge depend

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upon the properties of the objects involved and upon the translations imposed upon these objects. Translations can change previous relations between the properties of the interacting objects. A change in relation can cause a change in the outcome of the interaction. For example, the width relation between a box with an opening and a block smaller than this opening may first be consistent with passing through, but after a rotation of the block may become consistent with support. The relations between object properties that emerge during the interaction and constrain its outcome are called dynamic object relations. Dynamic object relations emerge and can change in space and over time. Since dynamic object relations constrain the outcome of the interaction, visual perception of these dynamic object relations allows for anticipation of this outcome.

Sitskoorn and Smitsman (1995) claim that dynamic object relations may be an effective unit for the perception of interactions in infancy because they are directly perceivable without perception of the components of which the relations are composed. They based this hypothesis on J. J. Gibson's view (Gibson, 1979) that relations between objects can be perceived directly to the extent that information specifying these relations is available for the perceptual system. For the visual system information is contained within invariances in the flow of stimulation in the optic array. A dynamic object relation involves a specific changing arrangement between the surfaces of the objects involved in the interaction. This changing arrangement transforms the structure of the optic array in a way that is specific to the object interaction. The specificity of this optical transformation to its source constitutes information for the dynamic object relation. Thus, a dynamic object relation that is consistent with passing through will structure the optic array differently than a dynamic object relation that is consistent with support. For example, a block smaller than the opening of a box, approaching this box in such a way that passing through will occur, will at some point start and continue to occlude the opening, inside structure, and back rim of the box for a perceiver looking upon the box. This optical transformation specifies passing through. If the translation of the block changes in such a way that the dynamic object relation becomes consistent with support, the block will start to occlude the opening, inside structure and back rim of the box and also its side rims. This optical transformation specifies a dynamic object relation that is consistent with support. Sensitivity to these optical transformations makes it possible to perceive a dynamic object relation as an invariant property of a specific interaction. Perceptual development involves an improvement in the ability to detect these kinds of invariants and consequential results in an increasing ability to anticipate the outcome of interactions.

In a series of experiments (Sitskoorn & Smitsman, 1995) evidence was collected for the hypothesis that infants perceive interactions on the basis of direct perception of dynamic object relations. However, infants' perception of the effects of translations upon relations between object properties was not studied yet.

A translation that imposes constraints upon the outcome of most mechanical interactions is the direction of approach of an object towards another object. Within a certain range, variations in the direction of approach may lead to similar outcomes of the interaction, that is, a block can pass through the opening of a box from a variety of approach directions. Beyond a certain range, a small variation in the direction of approach may lead to different relations between the object properties and, therefore, a different outcome of the interaction; that is, as soon as the descending block approaches the rims of the box, the passing through relation may change into a support relation, and the outcome of the interaction will be support. In this study, we investigated infants' ability to perceive whether the direction of approach of a block towards a box with an opening on top should result in passing through or in support.

EXPERIMENT 1: PASSING THROUGH AN OPENING

Rationale

We presented infants with several variations of a block approaching the opening of a box. During familiarization and lawful test trials (first 3 columns, Figure 1), all the instances of approach were consistent with passing through. During violation test trials, the approach was consistent with support but the outcome of the interaction

resulted miraculously again in passing through. If infants are able to perceive which outcome is constrained by a certain direction of approach, longer looking times may be expected for an event outcome that violates this perception than for an event outcome that is consistent with this perception.

METHOD

The method used was similar to that of Sitskoorn and Smitsman (1995).

Sample

Three groups of 20 infants participated: 6-month-olds (*M* age = 6 months 4 days, range = 5 months 23 days to 6 months 9 days), 9-month-olds (*M* age = 9 months 5 days, range = 8 months 28 days to 9 months 11 days), and 12-months-olds (*M* age = 12 months 2 days, range = 11 months 27 days to 12 months 6 days). An additional 5 infants were excluded from the experiment: 2 because of emotional distress, 1 because of equipment failure, and 2 because their caretakers did not follow the instructions given by the experimenter. Names and addresses of the participants were obtained from the municipal government in Nijmegen, The Netherlands. Parents were compensated for participation.

Objects

A box and a solid block were used (Figure 1). The block (10 x 13 x 6.5 cm) was made of wood and was painted red. The box (27 x 10 x 21 cm) had an opening of 20 x 18 cm. The box was made of translucent plastic. It was dappled randomly with yellow spots to provide obvious texture and to emphasize its substantiality without losing its translucency. The inner back side of the box was covered with black cardboard to emphasize the width of its opening. The box had a rim 7 cm in width on one side and rims 1 cm in width on the three other sides. The block fit into the opening of the box. The rim of 7 cm was partly flexible. Whenever the block touched this rim, the flexible part was pushed downwards, and the block could enter the opening of the box, apparently through the rim. When the block was raised again, springs underneath the rim pushed the flexible part back into its original position. The dapples on the box concealed the joints of the flexible part of the rim. The outline of the downward and upward moving block concealed the downward and upward motion of this flexible part. This ensured the illusion that the block was penetrating the opening through the rim. Precise matching of the flexible part of the rim with the depth of the block ensured that the block entered the box in a straight motion without jiggling.

Apparatus

The apparatus was a large wooden box with a 57 × 40-cm opening. The opening could be occluded by a black blind that was operated by an experimenter with the aid of a cord. Horizontal displacements of the box in relation to the block took place behind closed blind. The block hung on nylon strings, and its motion was controlled by the experimenter with the aid of a handle. The nylon strings were guided by two steel guides that prevented the block from swaying back and forth. These guides were not visible to the infants. The block moved at a constant speed of 20 cm /s, controlled by a regulator. The timing of the raising, lowering and holding of the block, and displacements of the box were indicated by a computer-controlled monitor.

Design

Infants were familiarized to a downward motion of a block through the opening of a box and a subsequent upward motion of the block to its original position. This event was considered one cycle. One or more cycles were shown in a trial, depending on the infants' looking time. The direction of approach of the block towards the opening of the box was varied by changing the position of the box in relation to the descending block. This procedure ensured that the direction of approach varied, but that the motion of the block was constant across trials. In familiarization trials passing through was demonstrated for two different directions of approach (see Figure 1). One interaction consisted of a downward motion of the block into the opening of the box with the large rim at the infants' right. The block approached the opening 1.5 cm from the large side rim, 8.5 cm from the small side rim and 6 cm from the front rim. The other interaction consisted of a downward motion of the block into the box with the large rim at the infants' left. The block approached the opening 8.5 cm from the small side rim, 1.5 cm from the large side rim and 6.5 cm from the front rim. Variations in the direction of approach on alternate trials provided the infants with the possibility of perceiving that within a certain range, different approach directions may be consistent with passing through.

After familiarization, a lawful and a violation test pair were shown (see Figure 1). The lawful test pair consisted of a downward motion of the block into the box with the large side rim at the infants' left side. The block approached the opening 0.5 cm from the small side rim, 9.5 cm from the large side rim, and 6.5 cm from the front rim. The violation test pair consisted of a downward motion of the block into the box with the large side rim at the infants' right. The block overlapped the 7-cm rim with 6.5 cm and the opening with 3.5 cm. This approach implied support. However, the block passed through the opening 6.5 cm from the front rim of the box and 16.5 cm from the small side rim.

For the lawful test pair, the event outcome (a) was similar to that seen in the familiarization phase, and (b) conformed lawfully to the outcome implied by the direction of approach of the block towards the box. For the violation test pair, the event outcome (a) was similar to that seen in the familiarization phase, but (b) violated the outcome implied by the direction of approach. Each test pair was shown twice. The four test trials were presented on alternate trials, counterbalanced across infants.

Procedure

The procedure was the same for all ages. Infants were tested while sitting on their caretaker's lap in front of the window of the display cabin. The eye level of the infant was adjusted by the height of the caretaker's seat such that the infants looked down at an angle of 40 degrees into the opening of the box. The infants were seated approximately 70 cm from the window. Caretakers were informed about the procedure and instructed not to look at the displays. If they nonetheless

looked at the displays, their infant was excluded from the experiment.

The durations of the looks of the infants, as indicated by corneal reflection, were scored in tenths of seconds by a hidden observer who observed the infant through a peephole of the display cabin. The durations of the looks were recorded with the aid of a button box connected to a computer. The observer was carefully trained but unaware of the specific direction of approach shown on a trial. Two observers watched 20 infants in order to determine interobserver-reliability. Interobserver-reliability on 0.5-s intervals of total looking time over trials averaged 94%.

A variant of an infant controlled familiarization of the visual looking time task was used (Horowitz, Paden, Bhana, & Self, 1972). The beginning of each trial was signaled by a tone that was also the sign for the experimenter to lift the blind. On each trial, the passing through event involving one of the two directions of approach was shown for one or more cycles. At the start of each cycle, the distance between the bottom of the block and the opening of the box was 20 cm. The block reached the bottom of the box in approximately 1.8 s. After 2 s, the block was raised in 1.5 s to its original position, where it hung for 1.5 s. Thereafter, the same 6.8 s. cycle was repeated. One or more cycles were shown in a trial depending on the infants' looking time. The infant had to look at the interaction for at least 2 consecutive seconds. If the infant had met this criterion, a trial was ended at the end of the cycle in which the infant continuously looked away for 2 s. The end of the trial was signaled by a tone which was the signal for the experimenter to slide the blind across the window. The blind occluded the display for 4 s. The next trial started with a different direction of approach.

Familiarization trials continued until the infant met the criterion of a 50% or greater decrease in looking time on two consecutive trials in relation to the looking time on the first two trials or after a maximum of 13 familiarization trials. The computer calculated when the infant met the criterion. After the infant met the criterion, the test trials were shown. The procedure for these trials was identical to the procedure of the familiarization trials with the exception that the direction of approach of the block towards the box was changed (see Figure 1).

RESULTS AND DISCUSSION

Familiarization

The mean number of familiarization trials to reach criterion was 5 for all age groups. No infant reached the maximum of 13 familiarization trials.

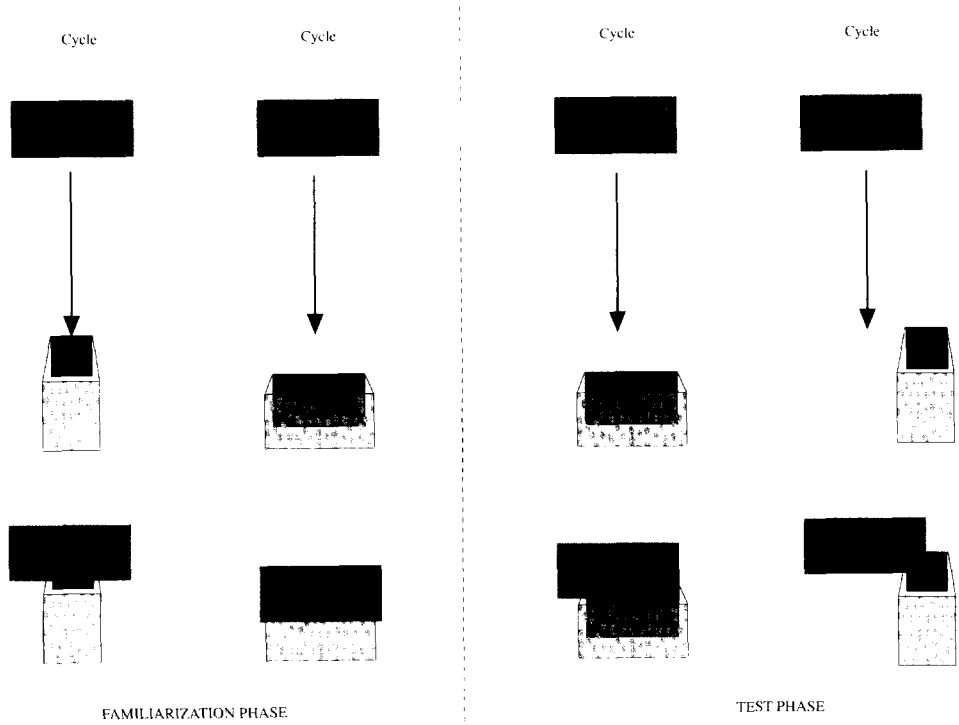

Figure 1. Schematic representation of the familiarization and test displays in the passing through an opening experiment.

Looking times

The infants' looking times were compared by means of a 3 × 2 × 2 mixed model analysis of variance with Age (6-, 9-, and 12-month-olds) and Order (Lawful test trial or Violation test trial first) as the between-subject variables and Test Pair (Violation and Lawful) as the within-subject variable. The analysis revealed a significant main effect of Test Pair, $F(1, 54) = 7.17$, $p < .01$. This main effect was qualified by a significant Age x Test Pair interaction, $F(2, 54) = 6.75$, $p <. 005$. Further analysis with Tukey's multiple range test ($p < 0.05$) revealed the following effects. The 12-month-old infants showed significantly longer looking times in the violation test trials than in the lawful test trials, whereas the 6- and 9-month-old infants did not (see Figure 2).

The results suggest that 12-month-old infants perceived that the direction of approach of the block towards the box in the violation test trials was not consistent with passing through. However, it is not clear whether or not they perceived that it was consistent with support. We performed a second experiment in order to determine whether and at what age infants perceive that certain directions of approach of an object towards another object are consistent with support, while others are not.

EXPERIMENT 2: SUPPORT

Rationale

Infants were presented with several variations of a block that approached the rims of a box and became supported by these rims. During the familiarization and lawful test trials (first 3 columns, Figure 3), all variations were consistent with support. During the violation test trials, the block only approached one rim of the box and became supported by this rim even though support was insufficient (right column, Figure 3). This variation was inconsistent with support. If infants are able to perceive which direction of approach is consistent with support, longer looking times may be expected for the violation test trials than for the lawful test trials.

METHOD

Sample

Three additional groups of 20 infants participated: 6-month-olds (*M* age = 6 months 5 days, range = 5 months 26 days to 6 months 12 day) 9-month-olds, (*M* age = 9 months 5 days, range = 8 months 25 days to 8 months 9 days), and 12-month-olds (*M* age = 12 months 6 days, range = 11 months

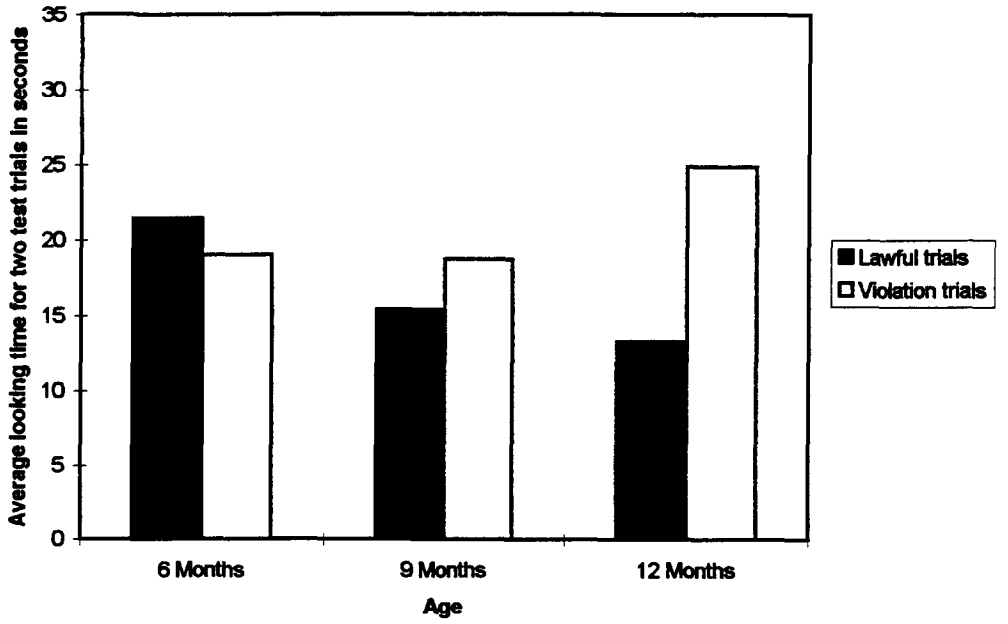

Figure 2. Average looking time for test pair scores for the three age groups in the passing through an opening experiment.

25 days to 12 months 11 days). An additional 6 infants were excluded from the experiment, 3 because of emotional distress, 1 because of equipment failure, and 2 because their caretakers did not follow the instructions given by the experimenter. The infants were similarly recruited as in Experiment 1.

Objects

Again a block and a box were used. The block was 17 x 8 x 10 cm and the box, 15 x 10 x 8 cm. The box had an opening of 7 x 14 cm. Both objects were made of the same materials as the objects of Experiment 1.

Apparatus

The apparatus was identical to that of Experiment 1 with one exception: After a downward motion of 36 cm the block was stopped by a piece of wood, 10 cm in height, placed beneath the handle that moved the block.

Design

Infants were familiarized to a block that was lowered to, and became supported by, the rims of a box and then was raised to its original position. In order to demonstrate support for two different directions of approach, the box was placed on alternate trials in two different horizontal positions with relation to the block. One support interaction consisted of an approach of the block towards the box ($8 \times 10 \times 15$ cm). The block overlapped both side rims of the box and extended 4.5 cm outward from each rim. A 7×2.5-cm part of the opening of the box remained visible in front of the block. The other event consisted of an approach of the block towards the box ($15 \times 10 \times 8$ cm). The block overlapped all rims by 1 cm (see Figure 3).

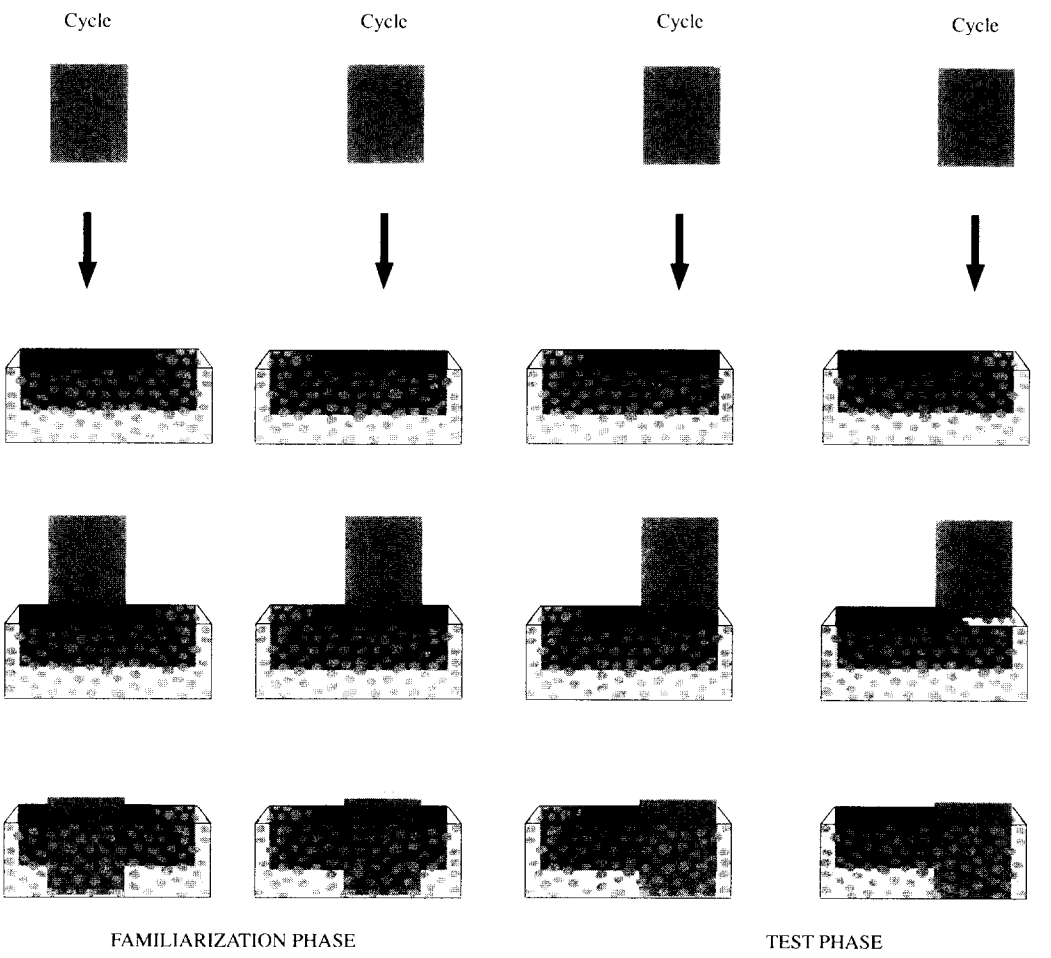

Figure 3. Schematic representation of the familiarization and test displays in the support experiment.

After familiarization, a lawful and a violation test pair were shown. The lawful test pair consisted of an approach of the block towards the box (15 × 10 × 8 cm) until it became supported by the left rim and the back rim of the box. The block overlapped the left side rim by 2.8 cm and the back rim by 1 cm. There was a small segment of the opening of the box visible. This segment was approximately 1 cm in depth in front and at the right side of the block. In this test pair, the direction of approach was consistent with support and, therefore, was similar to the direction of approach seen in the familiarization trials. The violation test pair consisted of an approach of the block until it became supported by the left side rim of the box (8 × 10 × 15 cm). The block overlapped the side rim by 10.5 cm and the back rim by 1 cm. Part of the opening of the box remained visible. This part was 1 cm in depth in front of the block, and 2 cm in depth on the right side of the block. Support was insufficient. In this test pair, the approach of the block towards the box was not consistent with support and, therefore, it was different from the approach shown in the familiarization trials. However, for both test pairs, a support outcome was shown.

Procedure

The procedure was identical to that used in Experiment 1. At the beginning of each cycle, the distance between the bottom of the block and the opening of the box was 26 cm. The block reached the top of the box in approximately 1.4 s, it remained steady for 2 s, then it was lifted in 1.8 s to its original position, where it hung for 1.5 s. Thereafter, the same 6.7-s cycle was repeated. As described earlier, the violation trials consisted of the block becoming magically supported by one rim of the box. Placing the piece of wood beneath the handle made this support outcome possible. The piece of wood was placed beneath the handle across trials throughout the whole experiment. This ensured that the same contact sound was heard across trials. After a familiarization criterion was reached, the test trials started.

RESULTS AND DISCUSSION

Familiarization

The mean number of familiarization trials was 5 for all age groups. None of the infants reached the maximum of 13 familiarization trials.

Looking Times

The infants' looking times were compared by means of a 3 × 2 × 2 mixed model analysis of variance with Age (6, 9, and 12 months) and Order (Lawful or Violation test trial first) as the between-subject variables and with Test Pair (Violation and Lawful) as the within-subject variable. The analysis revealed a significant main effect of Test Pair, $F(1, 54) = 12.54$, $p < .001$. This main effect was qualified by a significant two-way Age × Test Pair interaction $F(2, 54) = 11.13$, $p < .001$. Further analysis with Tukey's multiple range test ($p < 0.05$) revealed the following effects: The 6- and 9-month-old infants did not have significantly longer looking times in the violation test trials compared to their looking times in the lawful test trials, whereas

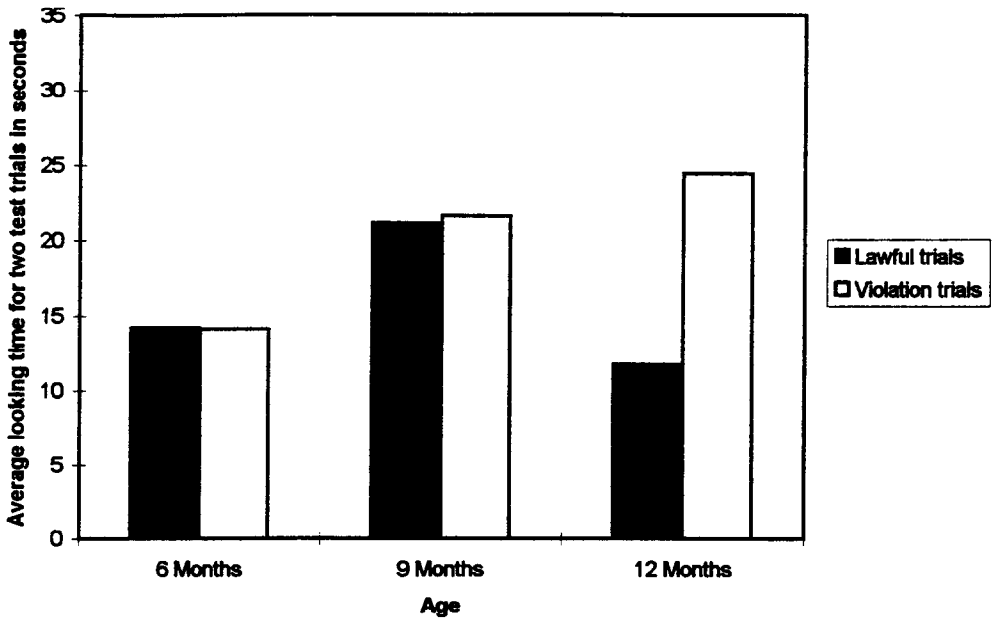

Figure 4. Average looking time for test pair scores for the three age groups in the support experiment.

the 12-month-old infants did show such a significant difference (see Figure 4).

The results suggest that 12-month-old infants, in contrast to 6- and 9-month-old infants, perceived that the direction of approach of the block towards the box in the violation test trials was not consistent with support. It was concluded that around 12 months of age, infants become able to perceive that certain directions of approach of an object towards another object are consistent with support, while others are not.

GENERAL DISCUSSION

The results of the present study show that 12-month-old infants, in contrast to 6- and 9-month-old infants, are able to anticipate that a small change in the direction of approach of a block towards a box with an opening on top is consistent with different event outcomes; that is, passing through or support. It may be concluded from these results that infants from 12 months of age do not just perceive an absolute relation between object properties, but that they take the translation of the interacting objects into account. This finding provides further evidence for the hypothesis that infants perceive interactions on the basis of dynamic object relations (Sitskoorn & Smitsman, 1995).

However, the negative results of the younger infants seem to be in contrast with the concept of dynamic object relations. Sitskoorn and Smitsman (1995) showed that infants from 6 months of age were able to perceive whether the relation between the width of a block and the width of the opening of a box specified support or passing through. The widths of the objects were varied, but the translation of the block was kept constant. Combination of these results with the negative results of the younger infants in the present study seems to suggest that infants younger than 12 months of age are able to perceive relations between absolute object properties but do not take the translation imposed upon the objects into account, that is, they do not perceive *dynamic* object relations. However, if the optical transformations shown to the infants of each study are compared, another explanation is possible.

In the study by Sitskoorn and Smitsman (1995) it was shown that occlusion of both side rims of the box by both sides of the block at the level of the opening of the box provided infants with information for support. Occlusion of none of the side rims, but only the inside structure of the box, provided the infants with information for passing through. In the violation test trials of the present experiments, the occlusion pattern did not consist of occlusion of only inside structure *or* occlusion of both side rims of the box by the block. In the violation trials of both the passing through and the support experiment, the pattern consisted of occlusion of one side rim of the box by one part of the block *and* occlusion of the inside structure of the box by another side of the block (most right columns of Figures 1 & 3). For infants with less well developed perceptual abilities, this could mean that in the violation trials of both of our experiments, there may have been information for both passing through and for support. Occlusion of the inside structure of the box by one side of the block may have provided them with information for passing through. Occlusion of a side rim of the box by a side of the block may have provided them with information for support.

In order to perceive the information specified by the occlusion pattern that occurs for partial collision, as in this study, more differentiated perception is necessary than for the information specified by the occlusion pattern that occurs for total or no collision. The requirement of more differentiated perception may explain the difference in age findings found in the present study and found between the present study and the former study by Sitskoorn and Smitsman (1995).

The results of the present support experiment seem to be in conflict with a previous experiment on infants' perception of support (Baillargeon, Needham, & DeVos, 1992). In the experiment of Baillargeon and her colleagues, infants watched an extended finger push a box along the top surface of a platform. In a lawful test trial, the block was pushed until it reached the end of the platform. In the violation test trial, the box was pushed until only one corner remained on the platform. Infants from 6.5 months of age looked longer at the violation than at the lawful test trial. It was concluded that infants perceive when an object is (in)adequately supported. In our experiment it was not until 12 months of age that infants showed this ability.

What can account for this contrast? In Baillargeon's experiment, the infants were presented with an object that already was supported and gradually lost its support. In the present support experiment, support was the outcome of an object approaching another object. Infants may perform better when shown violations that involve visibly supported objects that lose their support but remain stable than when shown violations that involve unsupported objects that gain inadequate support by a translation and remain stable (see for a similar explanation Needham & Baillargeon, 1993).

The results of the passing through experiment also seem to be in contrast with the results of comparable studies on infants' perception of solidity (e.g., Baillargeon, 1985, 1986, 1987a, 1987b; Spelke et al., personal communication). These studies showed that infants from 2.5 months of age onwards perceive that an object cannot continue its path when it approaches another object that is fully placed on its path. These studies suggest that very young infants are already sensitive to solidity. In our study, 6- and 9-month-old infants were not surprised when they saw a block passing, with one side, through the rim of a box that was placed on its path. This finding suggests that the infants in our study did not take solidity into account.

An explanation of these contrasting results just in terms of Spelke's core knowledge thesis is difficult. On the basis of her thesis, we would expect that by 6 months of age, infants' would readily perceive the violation of solidity in our passing through experiment. The contrast may be caused by differences in procedure. However, another explanation is possible. All of the studies that showed that infants younger than 12 months of age are able to perceive violation of solidity, provided infants with full collision events. No study, except the present one, used partial collision events. The contrasting results, therefore, seem to fit the previous explanation. Perception of partial collision requires more differentiated perception than perception of full or no collision, because in the case of partial collision, the resulting occlusion pattern is more ambiguous. Therefore, sensitivity to solidity in full collision events will develop earlier than sensitivity to solidity in partial collision events.

At first, one may question this explanation because the previous studies on infants' perception of solidity almost all used a hidden displacement paradigm. One may argue that because of this paradigm, infants had no access to occlusion patterns and that, therefore, the results cannot be explained in terms of perception of optical information but have to be explained solely in terms of reasoning (Spelke et al., 1992). However, we argue that in these studies, occlusion patterns that specified the interactions were still available and always needed to be perceived because understanding of solidity in itself is insufficient for perception of particular object interactions. In order to perceive what will happen when an object of a particular shape and size approaches another object, infants always need to attend to optical information such as occlusion, that specifies the objects' shapes, sizes, and trajectories. This is true for visible as well as for hidden displacement.

One typical experiment on infants' perception of solidity by Baillargeon (1986) may serve as an example. In this study, infants from 6 months of age were presented with events in which a toy car rolled on rails behind a screen that hid a box. In some conditions, the box was placed on the rails and obstructed the path of the car; in others, it was not placed on the rails, so did not obstruct the path of the car. The place of the box, and the covarying occlusion pattern, full or no occlusion of the rails, was shown before the beginning of a trial. Subsequently, the screen was put in place. Regardless of the place of the box, the car always reappeared at the far side of the screen. Infants looked longer in the condition where the box was placed upon the path of the car than in the condition where the box was not placed on its path. These results suggest that infants from 6 months of age perceived that the car could not have passed through the space occupied by the box that was placed fully on the rails. Infants might have based this perception upon perception of full or no occlusion of the rails before the beginning of a trial. It would be interesting to investigate infants' perception of solidity in a situation where the box only partially obstructed the path of the car.

Our explanation for the age differences found between studies on infant perception of interacting objects is in accordance with the theory of progressive differentiation of E. J. Gibson (1969). According to this theory, perceptual

development involves the progressive differentiation in abstracting invariant properties from transformations in the optic array. Progressive differentiation results in increasing correspondence of perception with the distal sources of stimulation in the environment. In order to understand infants' perception of interactions in general and the development of progressive differentiation in particular, further research on infants' perception of optical variables is needed.

AUTHORS' NOTES

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