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## Development as Progressive Inhibitory Control of Action: Retrieval of a Contiguous Object

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A conception of development is offered emphasizing that the child must not only acquire knowledge, but must also inhibit reactions that get in the way of expressing knowledge that is already present. In Experiment 1, 60 infants—12 each at 7, 8, 9, 10, and 11 months of age—were tested with a rectangular toy and a small box open at the top. All succeeded when the toy was in the box not touching the front wall, and in all conditions of contiguity where the toy could be retrieved by reaching along a straight line. However, all 7-month-olds failed the contiguous condition when required first to reach over the front wall and then back for the toy. Eleven-month-olds succeeded from the outset; 8 to 10-month-olds benefited most from experience during testing. In Experiment 2, 16 infants of 7 months and 8 infants of 10 months retrieved the toy under all conditions of contiguity where any portion of the toy was in front of the wall, extended farther from the wall than one half the wall's height, or rose to the same height as the wall or higher. In all of these conditions, the toy could be retrieved by reaching along a straight line. Seven-month-olds failed to retrieve the toy, however, even when it did not share a boundary with the front wall of the box, if distance from wall plus width of toy was less than half the wall's height. Here, infants had to first reach over the front wall and then reverse direction to retrieve the toy. Seven-month-olds touched the edge of the box significantly more often on these trials, and reacted to those touches by reflexively grasping the box or withdrawing their hand. We conclude that 7-month-old infants understand that an object is still there when it shares a boundary with another object (contrary to the theorizing of Piaget and of Bower).

Experiment 1 was supported by NSF BNS-8013-447. We would like to thank Fernando Vidal and Jody Sabia for their tireless help in scheduling and recording the testing sessions. Portions of Experiment 1 were reported at the International Conference for Infant Studies, Austin, TX, April 1982. Experiment 2 was supported by NIMH #1 ROI MH/HD41842-01 and by a grant from the McDonnell Center for Studies of Higher Brain Function, Washington University School of Medicine. We would like to thank Johanna Grant Nicholas for her excellent help in pretesting and Nathan Braverman for carefully coding videotapes. Portions of Experiment 2 were reported at the Society for Research in Child Development Meeting, Baltimore, MD, April 1987. Comments by Jerome Kagan and Michael Posner on an earlier draft are gratefully acknowledged.

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Failure to retrieve the contiguous object is due to lack of precision in executing a detour reach and an inability to inhibit reflexive reactions to touch.

By 7 months, infants are capable of readily retrieving a free-standing object. They are unable, however, to retrieve that object if it borders another, slightly larger object (Bower, 1974, 1977; Bresson, Maury, Pieraut-Le Bonniec, & Schonen, 1977; Bresson & Schonen, 1977; Piaget, 1954 [1937]; Schonen, 1982; Schonen & Bresson, 1984; Wishart & Bower, 1984, 1985). Piaget and Bower have hypothesized that this selective failure to retrieve occurs because infants have not yet acquired the concept of contiguity, that is, infants do not understand that an object continues to exist when it shares a boundary with another object: "It seems that what the baby doesn't understand is that two objects can be in a spatial relationship to one another, so that they share a common boundary. Evidently it is the common boundary that is critical" (Bower, 1977, pp. 116-117).

We suggest that the developmental task is not to elaborate the concept of contiguity but to inhibit reactions that get in the way of demonstrating this conceptual understanding. By 7 months, infants may understand that an object is still there when it borders another object yet fail to retrieve the target object because they are not yet fully able to inhibit reflexive reactions to touch, that is, the grasp and avoidance reactions (Twitchell, 1965, 1970).<sup>1</sup> If they accidentally graze the neighboring object en route to the target, they reflexively grasp or reflexively pull back. The key variable, then, is not contiguity but whether the infant can reach the object without contacting anything en route. By 7 months of age, infants are likely to arrive at their goal without contacting anything on the way if they have a direct, unobstructed route to the goal. If, however, they must first reach along one direction to avoid the neighboring object and then change direction to obtain their goal, they are more likely to touch the neighboring object en route.

This paper reports the results of two experiments. Experiment 1 had two goals: (1) to replicate the finding of Bower that infants fail to retrieve an object when it is directly behind a small wall but succeed when the object is a few inches behind the wall, and (2) to see if there were any conditions of contiguity where infants would succeed using the same object bordering the same wall as in (1). The results of Experiment 1 led us to the hypotheses tested in Experiment 2. Experiment 2 directly tested conditions of contiguity versus non-contiguity crossed with conditions of direct access to target versus two-directional reach required to target.

<sup>1</sup>According to Twitchell, the grasp reaction is not fully formed until after 4 months and then becomes less easily and reliably elicited by the last months of the first year. It would be most likely to occur in situations where the infant is primed to grasp, as in the experiments that have studied contiguity, where the infant is reaching out to grasp a toy. The avoidance reaction is fully formed by 24-40 weeks and consists of withdrawing or springing the hand back in response to contact. A touch too slight to trigger a grasp is often sufficient to trigger the avoidance reaction.

Table 1. Ages of Subjects in Experiment 1

Age, Months	Mean Age, Weeks (Days)	Age Range, Weeks (Days)
7	33 (3)	32 (4) to 34 (1)
8	36 (5)	35 (0) to 38 (4)
9	41 (1)	40 (0) to 43 (0)
10	45 (4)	44 (1) to 47 (1)
11	49 (4)	47 (5) to 51 (0)

## EXPERIMENT 1

### Methods

**Subjects.** Sixty infants, 12 each (6 male, 6 female) at 7, 8, 9, 10, and 11 months of age, were tested (see Table 1). All were full-term and healthy. They were located through the Boston birth records, and parents were called to invite their participation. No infant was tested if hungry, sleepy, or cranky.

**Materials.** Two boxes were used, both constructed of Plexiglas, one transparent and one opaque white. The base of each box measured 4.5 × 4.5 in., and all walls were 2.5 in. high. The boxes had no top and no back wall. All open edges were bordered by tape to protect the infants from cuts.

A red, rectangular Lego building block, measuring 2.5 × 1.25 × 0.75 in., was used on all test trials. It was always placed with one of the 2.5 × 0.75 in. sides down and the open side of the block toward the front wall of the box.

The testing table was 27.5 in. high. The tabletop was 20 × 24.5 in., and constructed of two wooden boards of equal size, with a 1-in. embedded wooden strip extending down the middle of the tabletop from front to back.

**Procedure.** Infants were required to retrieve the Lego building block from one of the Plexiglas boxes. The boxes were always placed so that the top was open. Experimental variables were: (1) location of the block: directly behind front wall of box, directly in front of front wall, or in center of box, (2) kind of box: transparent or opaque, and (3) orientation of box: flat on table or tipped forward with base of front wall as fulcrum. Thus, there were four conditions of contiguity: (a) directly behind transparent wall, (b) directly in front of transparent wall, (c) directly behind opaque wall, and (d) directly behind transparent wall, box tipped forward. In addition, the effect of observing the experimenter pick up the toy from behind the front wall, raise, and lower the toy back down in place was tested.

Infants were given time to become acquainted with the laboratory testing room and the experimenter. During this period the experimenter asked the parent

for demographic information and explained the testing procedure. The infant was then seated on the parent's lap, facing the wooden testing table. The parent's chair was adjusted so that the infant's shoulders were 4-5 in. above the tabletop. The experimenter sat opposite parent and child.

Before the start of each trial, (1) the infant's midline was aligned to the midline of the table, (2) the experimenter placed the toy in the box, and (3) the parent restrained the infant's arms. A trial began with the experimenter placing the box and toy on the table 5 in. from the front edge of the table, and the parent releasing the infant's arms. Infants were given unlimited time to retrieve the toy. If an infant became distracted, the experimenter tapped the box to regain the infant's attention. Both parent and experimenter offered words of encouragement throughout a trial, and praised the child happily after retrieval. The parent was not permitted to provide any specific advice by word or action, however. A trial ended when the infant retrieved the toy or refused to try any longer. After successful retrieval, infants were allowed to play with the toy during the intertrial interval.

Infants were not permitted to pick the box up off the table, tip the box forward, or tilt the box so that the toy slid out the back, out of reach of the infant. If an infant attempted to do this, the experimenter exerted downward pressure on the back corners of the box. The experimenter ensured that the box stayed in front of the infant's midline. However, infants were permitted to pull the box toward themselves and to lean and look in the box. All sessions were recorded on videotape from behind a one-way mirror.

Infants were familiarized with the transparent box and with retrieving toys from it during two preliminary training trials where a toy other than the Lego building block was placed in the center of the transparent box. These trials also served to screen out infants unable to retrieve a toy from the center of the box. One 7-month-old infant was unable to do this and so was not tested further.

The sequence of test trials was as follows:

- Trial 1: building block inside transparent box, bordering front wall
- Trial 2: building block in center of transparent box
- Trial 3: building block inside transparent box, bordering front wall
- Trial 4: building block inside transparent box, bordering front wall,
  - for half the infants: Experimenter raised and lowered the toy (referred to as "trailing the toy") (trial 4a)
  - for half the infants: Experimenter tipped the box forward (trial 4b)
- Trial 5: for half the infants: building block inside *opaque* box, bordering front wall (trial 5a)
  - for half the infants: building block *outside* transparent box, bordering front wall (trial 5b)
- Trial 6: building block inside transparent box, bordering front wall.

Trial 2 was a control on motivation. If the infant retrieved the toy on trial 2, then it is unlikely that failure on trial 1 or 3 would be due to lack of interest in the toy. Trial 3 was included primarily to control for order effects. Trials 4-6 further explored the conditions under which infants would err and the effects of experience on performance.

To "trail the toy," the experimenter grasped the Lego block from behind the front wall of the box and slowly raised the block in a vertical line above the box, returning it to its original position. Infants always watched this attentively and usually tried to reach for the toy, following with their own hand the movement of the experimenter's hand and the toy.

The experimenter tipped the box by picking up the back edges of the left and right sides of the box and tipping the box toward the infant with the base of the front wall as a fulcrum. The box was maintained in this position for the duration of the trial.

Trials 4a and 4b, and 5a and 5b, were each administered to only half the infants because of concern that the infants would not continue to work for the same toy over more than six trials, especially a Lego block, which neither squeaks nor rattles.

### Results

The results are shown in Table 2. Every infant successfully retrieved the toy when it was in the center of the transparent box (trial 2). However, less than half the infants succeeded when the toy was directly behind the front wall of the transparent box (trials 1 and 3). No infant succeeded on trial 1 and failed trial 3, although four infants failed trial 1 and succeeded on trial 3. The difference between performance on trials 1 and 3 was not significant. Performance on trial 2, however, was significantly better than on trial 1 ( $\chi^2 = 31.03$ ,  $p = .0005$ , McNemar, one-tailed) or trial 3 ( $\chi^2 = 27.04$ ,  $p = .0005$ , McNemar, one-tailed).

No infant failed for lack of trying. Nor did any infant fail because of insufficient manual dexterity to grasp the building block when it bordered the front wall. Those who failed never touched the toy. Typical behaviors of infants who failed were: (a) trying to reach through the front wall of the box, and (b) pulling the box toward themselves, leaning over, and looking in through the open top of the box, accompanied by either no reach, a reach that stopped before completion, or a reach too far back in the box, missing the toy entirely. Sequences (a) and (b) were usually repeated several times during a trial.

Infants who succeeded on trials 1 and 3 typically did so by: (a) pulling the box toward themselves, leaning and looking in the top of the box, and then reaching in and retrieving the toy, or (b) reaching over the front wall of the box and grasping the toy without any attempt to lean and look through the top of the box.

**Other Conditions of Contiguity.** All infants at all ages succeeded when the box was tipped forward (trial 4a) and when the box was opaque (trial 5a). All but

Table 2. Percent of Infants Successfully Retrieving Toy by Type of Trial and Age of Infant

	Age in Months					Total
	7	8	9	10	11	
Trial 1 (toy behind front wall)	0	33	58	50	83	43
Trial 2 (toy in center of box)	100	100	100	100	100	100
Trial 3 (toy behind front wall)	8	33	67	58	92	52
Trial 4a (box tipped forward)	100	100	100	100	100	100
Trial 4b (experimenter trailed toy)	0	33	67	83	100	57
Trial 5a (opaque box; toy behind front wall)	100	100	100	100	100	100
Trial 5b (toy in front of box)	83	100	100	100	100	97
Trial 6 (toy behind front wall)	8	58	83	83	100	67

*Notes.*

For trials 1, 2, 3, and 6,  $N$  per cell equals 12; total  $N = 60$ .

For trials 4a, 4b, 5a, and 5b,  $N$  per cell equals 6; total  $N = 30$ .

All trials were performed with the transparent box, except trial 5a.

The toy bordered the front wall of the box on all trials except trial 2.

one infant succeeded when the toy was placed outside the box bordering the front wall (trial 5b). (See Table 2). Performance on each of these trials was significantly better than that on trial 3 ( $\chi^2_s \geq 12.07$ ,  $p \leq .0005$ , McNemar, one-tailed) and significantly better than chance ( $Z$  scores  $\geq 4.9$ ,  $p \leq .0001$ ).

When the opaque box was used, infants pulled the box toward themselves, leaned and looked in, and retrieved the toy. There were almost no instances of reaching over the front wall without first leaning and looking through the top on opaque box trials. When the box was tipped forward or the toy placed outside the box, infants simply reached straight for the toy.

Thus, infants succeeded when the Lego block and front wall were not contiguous, and when they were contiguous but the box was tipped forward, the box was opaque, or the Lego block was in front of the box. Performance was significantly worse, however, when the block was directly behind the front wall of the transparent box.

**Effect of Experience.** The experience of retrieving the toy from the center of the box (trial 2) did not significantly improve performance when the toy was

again placed behind the front wall (trial 3), for performance on trial 3 was not significantly better than on trial 1.

During trial 4b infants saw the experimenter pick the toy up from behind the front wall of the transparent box, slowly lift the toy up above the box, and then return the toy to its position. Only two infants who had failed trial 3 were helped by this trailing sequence on trial 4b. Trailing the toy had no significant effect even though infants followed the toy with their hand as the toy was lowered back into the box. The toy and the experimenter's hand proceeded inside the box but the infant's hand remained outside. Thus, even this attempt at aiding the infants did not enable them to retrieve the building block from directly behind the front wall of the box.

Almost one third of the infants who could not retrieve the toy from directly behind the front wall of the box on trials 1 and 3 were able to do so on trial 6. Performance on trial 6 was significantly better than performance on trial 3 ( $\chi^2 = 4.92$ ,  $p = .05$ , McNemar, two-tailed).

Of the 14 infants who failed trial 3 and were tested with the opaque box on trial 5a, 8 infants (57%) succeeded on trial 6. Of the 15 children who failed trial 3 and were tested with the toy outside the box on trial 5b, only 3 (20%) succeeded on trial 6. Infants tested with the opaque box performed better on trial 6 than did infants tested with the toy outside the front wall ( $p = .04$ , Fisher's exact test, two-tailed).

Although performance improved with the toy directly behind the transparent wall from trial 3 to trial 6, performance on trial 6 was still significantly worse than performance on trials 2 (toy in center), 4a (box tipped forward), 5a (opaque box), and 5b (toy outside box) ( $\chi^2_s \geq 6.13$ ,  $p \leq .01$ , McNemar, one-tailed). Thus, the difference in performance between toy directly behind transparent wall and the other conditions cannot be attributed to any order effect because it was significant for earlier testing (trials 1 and 3) and for later testing (trial 6).

**Age Differences.** There was a clear age progression in performance ( $\chi^2 [4] = 19.62$  for trial 3,  $p < .001$ , two-tailed) and in the ability to profit from experience on this task (change in performance from trial 3 to trial 6 over age:  $\chi^2 [4] = 24.75$ ,  $p < .001$ , two-tailed). Almost all 7-month-olds failed when the toy was directly behind the transparent walls (trials 1 and 3). (See Table 2.) Not only were infants of 7 months unable to retrieve the toy from behind the front wall of the transparent box, but they showed no improvement in performance following experience. Infants of 8 to 10 months were able to benefit from experience, as can be seen by their improved performance on trial 6 (trial 3 vs. trial 6:  $\chi^2 = 10.08$ ,  $p < .01$ , McNemar, two-tailed). By 11 months, infants succeeded on trial 1, without any prior experience.

There were no significant effects by sex.

### Discussion

There were two major findings from Experiment 1. First, almost all infants of 7 months and even some who were 8 to 10 months old failed when the toy was

directly behind the front wall of the transparent box, even though they readily retrieved the same toy from the center of the same box. This replicates the findings of Piaget and Bower that infants fail to retrieve an object when it borders another, even though they are able to retrieve either object when it is free-standing.

However, the second major finding was that some 7-month-old infants succeeded even under other, very similar, conditions of contiguity. Infants who failed to retrieve the toy when it was directly behind the front wall of the transparent box nevertheless successfully retrieved the same toy from the same position in the same box when the box was tipped forward, when the opaque box was used with the toy in the same position, and when the toy was outside the transparent box, bordering the front wall. Recall that Piaget and Bower had theorized that infants should fail under all conditions of contiguity. Yet, here the toy and wall were contiguous, and infants succeeded.

Although a Lego building block is not as attractive as some other objects, the motivational explanation that infants failed when the block was inside the transparent box bordering the front wall because they did not want the block can be further rejected because: (1) Under all conditions, using the same building block, infants succeeded. (2) As soon as the trailing sequence began, infants reached for the toy eagerly. (3) No infant failed by not trying to get the toy. (4) Infants often became upset at their failure to get the toy. (5) This fussing and crying stopped if the infant was permitted to have the toy.

Success on trial 2 cannot simply be attributed to greater experience with the task or familiarity with the situation, because infants failed again on trial 3 (toy again inside transparent box, bordering front wall).

When the toy was in the center of the box (trial 2), infants could reach and retrieve on a straight line. Moreover, when the box was tipped forward (trial 4b) and when the toy was outside the box (trial 5b), infants were also able to get to the toy on a straight line of reach (see Figure 1). On all these trials, infants succeeded.

Conversely, when the toy was inside the box bordering the front wall, it was not possible to reach the toy on a straight line. First, infants had to reach along a diagonal to clear the wall, and then reverse direction to retrieve the toy (see Figure 1). It was not possible to clear the barrier *and* reach for the toy without changing direction. The two-directional reach required here is more difficult than simply reaching straight for the toy, and involves an indirect route to one's goal, not unlike means-end behavior.

By 7 months infants are physically capable of a reach that changes direction, but we would like to suggest that the increase in difficulty of such a reach is just enough so that infants are less likely to clear the front wall of the box cleanly, without contact. Once their palm or fingers touch the edge of the front wall, infants reflexively grasp or reflexively withdraw, halting the reach.

For a long time, we could not account for the success of infants with the opaque box. This should have required a two-directional reach just as did the

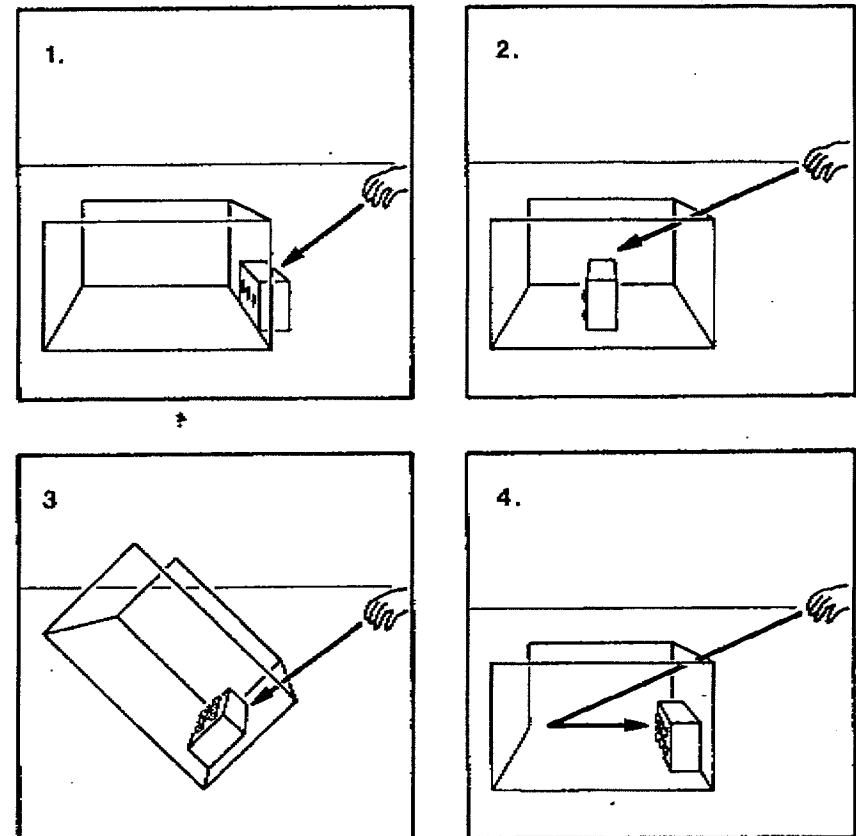


Figure 1. Infants could reach on a straight line for the toy in all conditions except when the toy was inside the transparent box, bordering front wall. (1) Toy outside transparent box, bordering front wall. (2) Toy inside transparent box, in center of box. (3) Toy inside transparent box, bordering front wall, box tipped. (4) Toy inside transparent box, bordering front wall. When the opaque box was used, the toy was placed in the same position as that pictured in panel 4.

comparable condition with the transparent box, yet infants succeeded with the opaque box but failed with the transparent box. To continue this work, an assistant was trained on the experimental procedures. Her first few testing sessions failed to replicate our original results, however. Infants of 7 months succeeded even when the Lego toy was directly behind the front wall of the transparent box. Puzzled by the inconsistency, we reviewed the videotapes of her sessions and noticed that she allowed the infants to pull the box much closer than had been allowed in Experiment 1. With the box in this position, when infants

leaned over they could reach straight down and retrieve the toy. No two-directional reach was required.

The assistant correctly pointed out that the instructions had not stated a limit as to how close the box could be pulled. In Experiment 1 the experimenter had tried to prevent infants from pulling the box closer than 4 in. from the front edge of the table, but this had never been explicitly stated and so never verified during coding of the videotapes. At the outset of a trial, infants could not see the toy when it was directly behind the front wall of the opaque box. Perhaps infants had been unintentionally allowed to pull the opaque box closer in Experiment 1 than they had been allowed to pull the transparent box. These trials were meant to be equal in all respects except for the transparency of the box, but perhaps the trials had differed in distance from the front edge of the table as well. We re-analyzed the videotape records for the 7-month-old infants who had been tested with the opaque box. Every infant had pulled the opaque box closer to the front edge of the table than the transparent box, matched pairs  $t(11) = 7.06, p = .001$ . Mean distance of front wall of box from front edge of table was 4.8 in. on trial 3 (toy directly behind front wall, transparent box) but only 2.5 in. on trial 5a (toy directly behind front wall, opaque box). (Mean distance of front wall of box from front edge of table ranged from 4.5–5.0 in. in the other conditions.)

Success with the opaque box no longer seemed an anomaly. Now, on *all* trials in which infants succeeded a direct reach for the toy was possible, and in the one condition in which they failed a direct reach was not possible. This is consistent with the results of others. Schonen (1982) found that infants have as much difficulty retrieving a toy from directly behind an opaque wall as they do in retrieving the toy from behind a transparent wall, when all other variables are held constant.

Thus, Experiment 1 demonstrated that there are conditions of contiguity where infants even as young as 7 months will succeed. In the conditions under which infants succeeded, they could reach for the toy on a straight line; in the condition in which they failed, a two-directional reach was required.

## EXPERIMENT 2

We predicted that infants would succeed when they could retrieve the goal without touching another object, even when the objects were contiguous (as shown in Experiment 1), and would fail when the nearby object was likely to be touched en route to the goal, *even if the goal and nearby object were not touching*. The key variable would be whether the infant could reach the toy without contacting the edge of the box en route. Infants would be likely to contact the edge of the box when they had to execute a two-directional reach but not when a simple direct reach would suffice. Thus, infants would succeed when a straight reach was possible and fail when a two-directional reach was required. We tested this against the prediction of Piaget and Bower that infants would

succeed when the toy was not contiguous with the front wall of the box but fail when the two objects were touching. Using the videotape records, each time an infant's hand touched the edge of the box, the reaction to touch was coded so that we could directly test our hypothesis concerning inability to inhibit reflexive reactions to touch.

## Methods

**Subjects.** Sixteen healthy, full-term 7-month-old infants (9 male, 7 female) were tested. The mean age was 31 weeks, 1 day. The range was 28 weeks, 5 days, to 33 weeks, 6 days. In addition, 8 older infants (5 male, 3 female) of 10 months were tested. Their mean age was 45 weeks, 5 days (range: 44(0)–48(5) weeks). All infants were located through the St. Louis City and County birth records. Parents were called and asked to participate.

**Materials.** Two transparent Plexiglas boxes were used. The base of one was 4.5 × 4.5 in., with walls 2.5 in. high (as in Experiment 1). The base of the other box measured 6 × 6 in., with 2 in. high walls. Both boxes had no top and no back wall. The toys were a red Lego building block (2.5 × 1.25 × 1.0 in.) and a thinner blue Snappies building block (2.5 × 0.63 × 1.0 in.). The testing table was 28.5 in. high. The tabletop measured 20.75 × 24 in.

**Procedure.** The infant's task was to retrieve a building block from one of the boxes. Testing procedures were similar to those in Experiment 1. Testing was conducted in the laboratory with the infant seated on the mother's lap with the infant's shoulders 4 to 5 in. above the tabletop.

Unless otherwise noted, the red building block and taller box (4.5 × 4.5 × 2.5 in.) were always used, the building block was always placed horizontally inside the box, and the front wall of the box was always kept 4 to 6 in. from the front edge of the table. The box was always placed so that the top was open.

The experimental variables were: (1) *distance of toy from front wall of box* (contiguous, in center of box, 0.5 in. from front wall), (2) *height of front wall* (2 in., 2.5 in.), (3) *width of toy* (1.25 in., 0.63 in.), (4) *distance of box from infant* (2–3.9 in. from front edge of table, 4 in. or more from front edge of table), and (5) *orientation of toy* (horizontal, vertical, or perpendicular to front wall of box).

It was predicted that infants would be able to reach on a straight line for the toy, and so would not touch the edge of the front wall en route, if (a) any portion of the toy were in front of the wall, (b) any portion of the toy lay farther from the wall than one half the wall's height, or (c) any portion of the toy rose to the same height as the wall or higher. It was further predicted that a straight reach would become more possible the closer the box was to the infant or the lower its front wall.

The baseline conditions were the toy bordering the front wall of the box

(contiguous; two-directional reach required) and the toy in the center of the box (not contiguous; straight line of reach possible). Here, the predictions of Piaget, Bower, and ourselves are indistinguishable. All would predict failure in the first case and success in the second. This had already been demonstrated in Experiment 1.

A set of conditions departed from baseline in that the toy bordered the front wall, but a straight line of reach was possible. Here, Piaget and Bower would predict failure; we predicted success. Conditions falling within this set were: toy in the vertical position bordering front wall (here height of toy was equal to height of front wall), toy bordering front wall but perpendicular to it (toy would then extend farther into the box than one half the height of front wall), box with shorter front wall (here, even in the horizontal position, the toy would extend into the box farther than one half the height of the front wall), toy outside box bordering front wall, and box less than 4 in. from the front edge of table.

Another condition departed from baseline in that the toy was not touching the front wall of the box, but a two-directional reach was required. The thinner blue toy was placed in the box 0.5 in. from the front wall. Piaget and Bower would predict success here; we predicted failure.

To test our hypothesis that infants succeeded with the opaque box in Experiment 1 because it was close to them but failed with the transparent box because it was far, we tested infants in Experiment 2 with the transparent box both close and far. We did not use the opaque box in Experiment 2 because it would be difficult to place it far from the infant and still have the infant be able to see the toy from the outset of the trial (many 7-month-olds will not reach for a hidden object).

All sessions were filmed from two cameras at different angles to permit detailed coding from the videotape. Two coders carefully recorded each reach the infant made on each trial, recording in particular whether the infant's hand touched the box, whether the infant withdrew his or her hand without touching the box at all, and whether the infant continued a reach and retrieved the toy despite making contact with the box. Responses to contact such as grasping or withdrawal were also recorded.

Testing began, as in Experiment 1, with two familiarization trials where a toy other than a Lego was placed in the center of the 4.5 × 4.5 × 2.5 in. box. All infants succeeded on these trials.

No infant received all experimental conditions because that would have required too many trials per child. The 7-month-old infants were divided into four experimental groups. The sequence of testing for each group is outlined in Table 3. Groups 1 and 2 received the same conditions but with order of presentation counterbalanced within test pair. For example, infants in group 1 were tested first with the toy in the perpendicular position and then vertical, whereas infants in group 2 received the vertical position first. Groups 3 and 4 were similarly matched. Half of the 10-month-old infants received the testing sequence for group 1 and half received the testing sequence for group 4.

Table 3. Testing Sequences for the Four Experimental Groups

Trial	Group 1	Group 2	Group 3	Group 4
1	Toy bordering wall	Toy in center	Toy bordering wall	Toy in center
2	Toy in center	Toy bordering wall	Toy in center	Toy bordering wall
3	Toy bordering wall	Toy in center	Toy bordering wall	Toy in center
4	Toy in center	Toy bordering wall	Toy in center	Toy bordering wall
5	Box near infant	Box near infant	Toy outside box	Toy outside box
6	Toy perpendicular	Toy vertical	Thinner toy, 0.5 in. from wall	Box with lower walls
7	Toy vertical	Toy perpendicular	Thinner toy, in center of box	Box with lower walls, box near infant
8	Toy outside box	Toy bordering wall	Toy bordering wall	Thinner toy, in center of box
9	Toy bordering wall	Toy outside box	Box with lower walls	Thinner toy, 0.5 in. from wall

*Notes.*

- Toy used was always the wider one unless otherwise specified.
- Toy was always placed horizontally unless otherwise specified.
- Toy was always contiguous with the front wall of box unless otherwise specified.
- Box with higher walls was always used unless otherwise specified.
- Box was always maintained 4–6 in. from infant unless otherwise specified.

## Results

The results for the first presentation of each experimental condition for the 7-month-old infants are considered first.

*Conditions Where Our Predictions and Those of Piaget and Bower Were the Same.* All infants failed to retrieve the Lego block when it was directly behind the front wall of the box,  $N = 16$ ,  $p = .0001$ , binomial, regardless of whether they received this condition first or were tested first with the Lego in the center of the box (see Table 4). This is consistent with all predictions, for the Lego and front wall were contiguous (so Piaget and Bower would predict failure) and the Lego could not be obtained by reaching on a straight line (so we predicted failure). As in Experiment 1, no infant failed for lack of trying; indeed they often persisted quite doggedly to get the toy.

All but one infant succeeded when the Lego block was in the center of the box,  $N = 16$ ,  $p = .0003$ , binomial. This, too, is consistent with all predictions, for the Lego and front wall were not contiguous (so Piaget and Bower would predict success) and infants could reach for the toy on a straight line (so we predicted success).

These results replicate those found in Experiment 1.

*Conditions Where Piaget and Bower Would Predict Failure and We Predicted Success.* There were six conditions where the Lego block and front wall of the box were contiguous but the Lego could be obtained by reaching on a straight line. Infants did well in all of these conditions.

Table 4. Percent Success, Mean Trial Duration, Mean Number of Touches to Edge of Box for 7-month-old Infants on the First Presentation of Each Condition

Distance Separating Toy and Front Wall, in.	Width of Toy, in.	Height of Toy, in.	Height of Front Wall, in.	Toy in Front of, or Behind, Front Wall	Distance of Front Wall from Infant, in.	Percent Succeeding	Mean Duration, Seconds	Mean Number of Touches to Edge
0 (adjacent)	1.25	1	2.5	behind	4-6	0 (16)	28.3	7.3
2 (center)	1.25	1	2.5	behind	4-6	94 (16)*	7.3*	1.5*
0 (adjacent)	1.25	1	2.5	in front	4-6	100 (14)*	3.2*	0.2*
0 (adjacent)	1.25	2.5 (vertical)	2.5	behind	4-6	100 (8)*	7.4*	2.5*
0 (adjacent)	2.5 (perpendicular)	1	2.5	behind	4-6	75 (8)*	15.7*	5.0
0 (adjacent)	1.25	1	2.5	behind	2-3.9	75 (8)*	16.6*	3.1*
0 (adjacent)	1.25	1	2	behind	4-6	57 (7)	14.7*	3.8*
0 (adjacent)	1.25	1	2	behind	2-3.9	100 (4)	12.8*	3.5*
0.5	0.63	1	2.5	behind	4-6	13 (8)	21.1	5.9
2	0.63	1	2.5	behind	4-6	100 (8)*	4.8	1.0*

\* = significantly different from performance with toy directly behind front wall (line 1) at  $p \leq .05$ . Matched pairs  $t$ -tests were used for duration and touches to edge of box. McNemar was used for success rate.

When the Lego block was outside the box, bordering the front wall, all infants succeeded ( $N = 14$ ) (see Figure 2A). Two infants in group 2 were so upset at not being able to retrieve the Lego from behind the front wall on trial 8 that they refused to try on trial 9. Even if these two infants had been included here, the results would be significant: 88%,  $N = 16$ ,  $p = .002$ , binomial. When the Lego was inside the box, bordering the front wall, in the vertical position (so that it was the same height as the box), all infants also succeeded ( $N = 8$ ). When the Lego was inside the box, bordering the front wall, in the perpendicular position (so that it extended farther into the box than one half the height of the front wall), 75% ( $N = 8$ ) of the infants succeeded (see Figure 2B). When the box was close to the infant (2 to 4 in.), 75% of the infants also succeeded ( $N = 8$ ). When the shorter box was used, most infants succeeded (57%,  $N = 7$ ; one infant in group 3 was so upset at not being able to retrieve the Lego from behind the front wall on trial 8, the infant refused to try on trial 9). When the shorter box was used and the box was close to the infant, all infants succeeded (see Figure 2C). Performance on all of these trials was significantly better than performance when the Lego was horizontal, behind the front wall, box 4-6 in. from the infant (outside box:  $\chi^2 = 10.08$ ,  $p = .005$ ; vertical:  $\chi^2 = 6.13$ ,  $p = .01$ ; perpendicular:  $\chi^2 = 4.17$ ,  $p = .025$ ; closer:  $\chi^2 = 4.17$ ,  $p = .025$ ; shorter box:  $\chi^2 = 2.25$ ,  $p = .07$ , closer and shorter box:  $\chi^2 = 2.25$ ,  $p = .07$ ; McNemar, one-tailed tests).

*The Condition Where Piaget and Bower Would Predict Success and We Predicted Failure.* When the thin building block was 0.5 in. from the front wall of the box, Piaget and Bower would predict success because the building block and front wall were not contiguous. We predicted failure because the block could not be reached on a straight line. Only one infant succeeded,  $N = 8$ ,  $p = .04$ , binomial. Performance here was not significantly different from performance with the wider toy bordering the front wall. All infants retrieved the thin block when it was in the center of the box ( $N = 8$ ). This performance was significantly better than chance,  $p = .004$ , binomial, and significantly better than their performance when the same toy was 0.5 in. from the front wall,  $\chi^2 = 5.15$ ,  $p = .025$ , McNemar, one-tailed (see Figure 2D).

*Performance over Repeated Presentations.* All 7-month-old infants failed to retrieve the Lego block from directly behind the front wall of the box on the first presentation ( $N = 16$ ). On the second presentation of this condition, most infants still failed. Success rate was only 19%,  $N = 16$ ,  $p = .01$ , binomial. Performance on the second presentation was not significantly better than performance on the first presentation.

On the third presentation at the end of the session, however, 50% of the infants succeeded ( $N = 12$ ). Performance on the third presentation was significantly better than performance had been on the first presentation,  $\chi^2 = 4.17$ ,  $p = .05$ , McNemar, two-tailed. Performance on this third presentation was still sig-



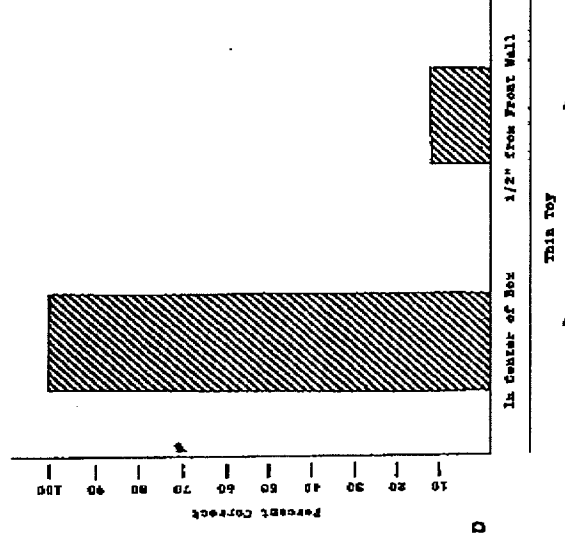
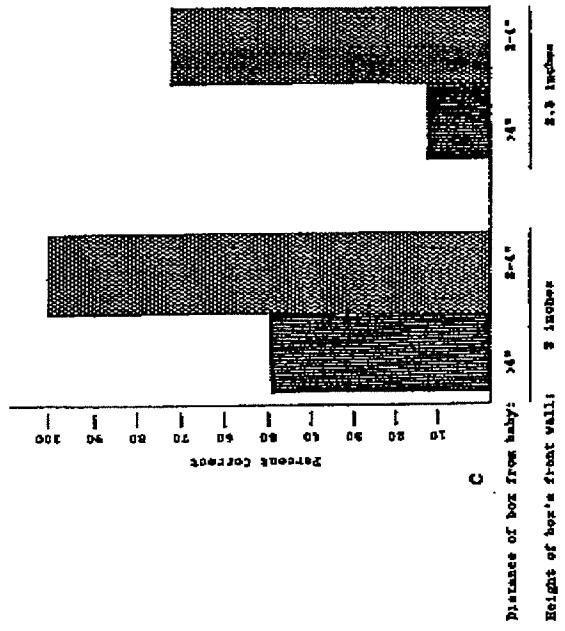
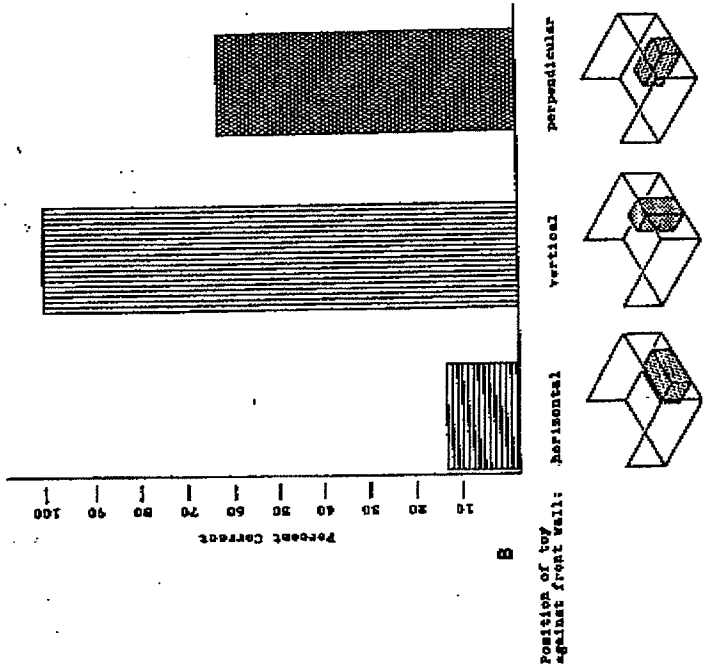
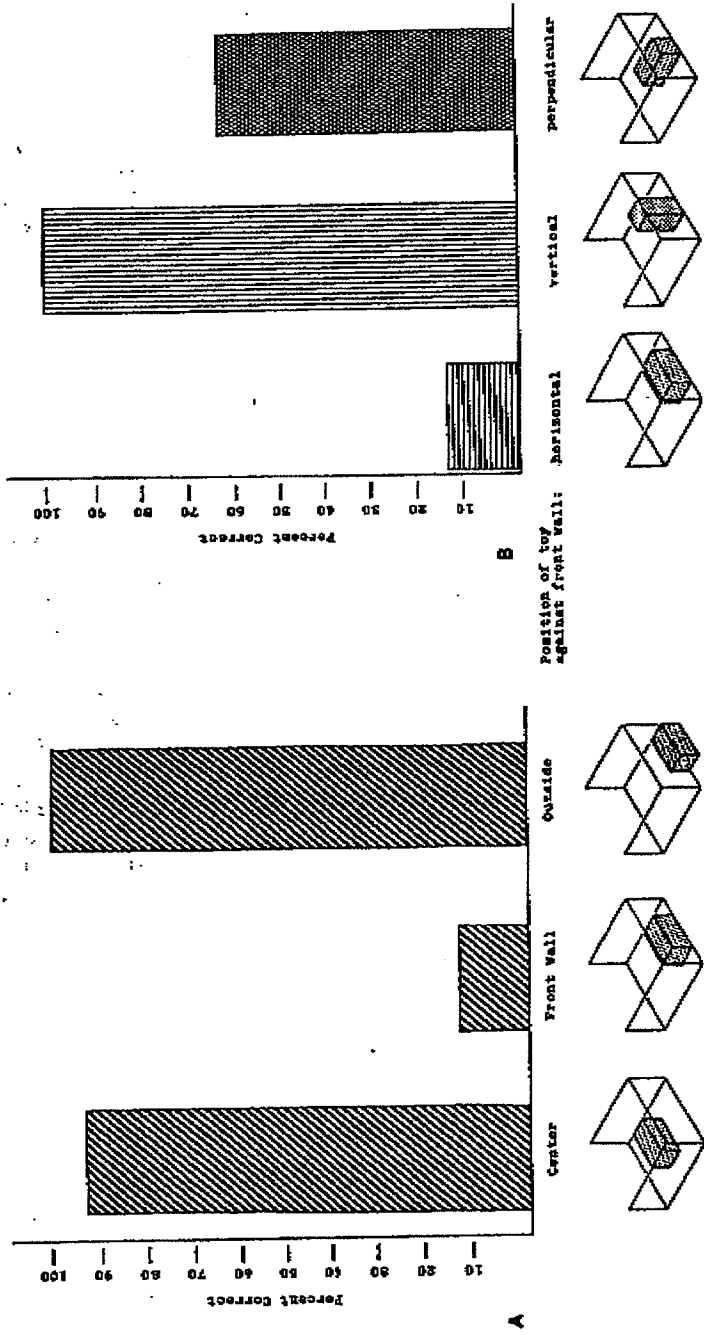


Figure 2. (A) Percent correct with the toy in the center of the box, directly behind the front wall, and outside directly in front of the front wall. (B) Percent correct with the toy horizontal, vertical, or perpendicular to the front wall. Toy was directly behind front wall in all conditions. (C) Percent correct by distance of box from the infant and height of the front wall of the box. Note that percent correct is lowest when the taller box is farther away, and percent correct is highest when the shorter box is closer. (D) Percent correct for the thin toy with the toy in the center of the box and 0.5 in. from the front wall. Box is drawn with front of box toward the lower right-hand corner of the page. Top and back of box are open.

nificantly worse, however, than performance with the toy in the center of the box ( $\chi^2 = 3.2, p = .05$ , McNemar, one-tailed), the toy outside the box ( $\chi^2 = 4.17, p = .025$ , McNemar, one-tailed), or the toy in the vertical position ( $\chi^2 = 3.2, p = .05$ , McNemar, one-tailed). Thus, performance with the Lego block directly behind the front wall of the box improved over testing, but it remained significantly worse than performance in other conditions.

There were no discernible effects by experimental group.

**Age Differences.** All 10-month-olds succeeded on all trials. From the very first presentation, they succeeded with the Lego block directly behind the front wall of the box. Their performance was, thus, significantly better than that of the 7-month-old infants (Fisher's exact test,  $p = .001$ ). No sex difference in either age group were observed.

**Reactions to Touch.** In the conditions characterized by failure, that is, the conditions requiring a two-directional reach—infants of 7 months were far more likely to touch the edge of the box than in conditions characterized by success. Thus, for example, when the toy was directly behind the front wall of the box, 7-month-old infants touched the edge of the box an average of 7.31 times during a trial, whereas when the toy was in the center of the box they touched the edge of the box only 1.53 times per trial, and when the toy was outside the box, bordering the front wall, they touched the edge of the box only an average of 0.43 times (see Figure 3A). Infants touched the edge of the box significantly more often when the toy was directly behind the front wall of the box or when the thinner toy was 0.5 in. from the front wall than when either toy was in the center of the box (wide toy against front wall vs. in center of box: matched pairs  $t(15) = 4.74, p = .0005$ , two-tailed; thin toy 0.5 in. from front wall vs. in center of box:  $t(15) = 4.54, p = .001$ ). Similarly, they touched the edge of the box more often when the Lego block was horizontal, directly behind the front wall, than when it was horizontal, directly in front of the front wall (outside the box),  $t(15) = 4.37, p = .0001$ , or when it was vertical, directly behind the front wall,  $t(15) = 3.47, p = .01$ . They touched the edge of the box more often when the box was far than when it was close to the infant,  $t(15) = 2.27, p = .05$ , and they touched the edges of the higher box more often than the edges of the box with lower walls,  $t(15) = 3.38, p = .01$ .

All 7-month-olds touched the edge of the front wall with their fingers or palm when the toy was directly behind the front wall. Fewer infants (56%) touched the edge when the box was in the center, but nine infants did touch the wall yet succeeded anyway when the toy was in the center.

Infants of 7 months reacted to these touches, especially if their palm touched, by reflexively grasping the box or reflexively withdrawing their hand. Grasping the box was more common than withdrawing. Sixty-eight percent of the times their palm contacted the edge of the box, they grasped the edge. An additional

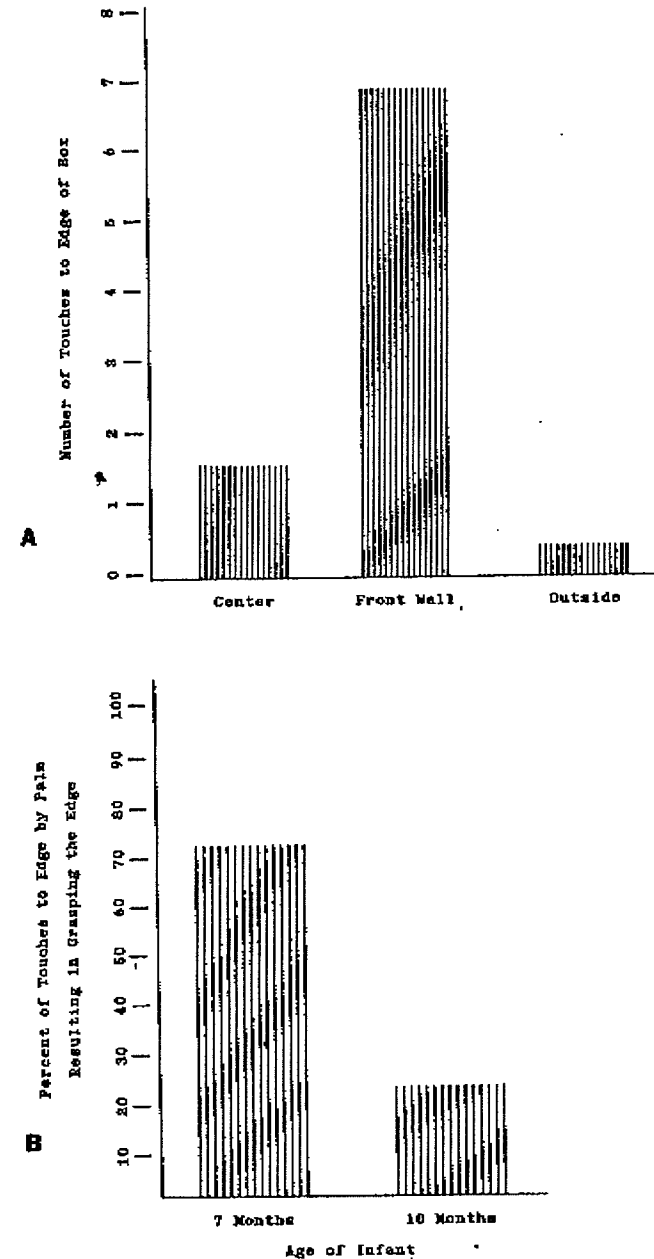


Figure 3. (A) Number of instances of touching the edge of the box when the toy was in the center of the box, directly behind the front wall, and outside directly in front of the front wall. (B) Percent of times 7-month-olds and 10-month-olds reacted to touching the edge of the box by grasping the edge.

15% of these contacts resulted in the infants jerking their hand back in the avoidance reaction.

The 10-month-old infants touched the edge of the box less often than the 7-month-olds. For example, when the toy was directly behind the front wall, they touched the edge of the box an average of 3.13 times per trial, versus an average of 7.31 for 7-month-olds,  $t(7) = 4.21, p = .01$ , two-tailed. Moreover, when they did touch the edge of the box, they were much less likely to react reflexively; instead they continued reaching for the toy (see Figure 3B),  $t(7) = 14.18, p < .0001$ .

Figure 4 presents part of the sequence of reaching for one 7-month-old infant when the toy was directly behind the front wall of the box. This illustrates the grasp and avoidance reactions. Although the infant was reaching for the toy and not for the box, he touched the box en route to the toy. In the first sequence he grasps the box. In the second sequence he withdraws his hand.

**Succeed When Look Away.** Five of the 7-month-olds (63%) who succeeded on the third presentation of the toy directly behind the front wall of the box did so as they were looking up. Having failed to get the toy, they had seemingly given up and were looking up at the experimenter, their hand grasping the front edge of the box. As they were looking up, they relaxed their grasp and their hand slid down and grasped the toy (see Figure 5). The infants looked down once their hand had touched the toy, but they appeared not to have been attending as their hand made its way down to the toy.

### Discussion

Most infants retrieved the toy under all conditions of contiguity where the toy lay in front of the box, the ratio of toy width to wall height was greater than 1:2 (toy perpendicular to front wall, or box with lower walls), the ratio of toy height to wall height was 1:1 (toy vertical), or the box was within 4 in. from the front edge of the table. In all of these conditions, infants retrieved the toy by a straight line of reach.

However, only 13% of the 7-month-old infants retrieved the toy, even when it was free-standing, if the distance from the wall plus the width of toy was less than one half of the wall's height (thinner toy, 0.5 in. from front wall). To reach over the front wall in this condition, infants had to first reach past the toy and then reverse direction to retrieve the toy.

In all cases, these results are consistent with our predictions and inconsistent with those that Piaget and Bower would make.

The 7-month-olds showed some improvement with practice, but their performance with the toy directly behind the front wall, ratio of toy width to wall height less than 1:2, at the end of the session was still significantly worse than their performance had been in the other conditions.

Infants showed every evidence of reaching for the toy and not for the box.



Figure 4. Top row: In reaching for the toy, infant accidentally touches the edge of the box, and reacts by reflexively grasping the edge. Bottom row: In reaching for the toy, infant accidentally touches the edge of the box, and reacts by reflexively pulling his hand back (avoidance reaction).

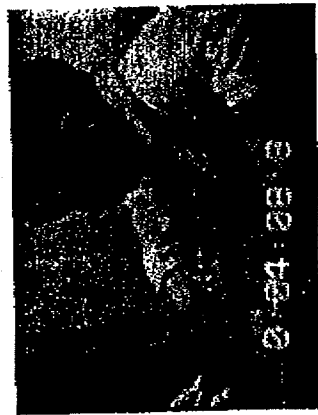


Figure 5. End of trial 6; infant has given up and is looking up at the experimenter. The infant's grasp of the edge of the front wall relaxes and her hand moves down to the toy. She never looks down until her hand is almost grasping the toy.

They either withdrew their hand upon touching the box or grasped the box and then withdrew their hand to try to reach again. Although Lego building blocks are less interesting for infants than are some other toys, no infant failed because of not trying, and whenever the building block could be reached on a straight line, all infants retrieved it.

Although the box was usually maintained 4 to 6 in. from the infant, infants did not fail because the toy was too far away. This can be seen by their success when the toy was in the center of the box, where, with the box still 4 to 6 in. from the infant, the toy was even farther away than when it bordered the front wall.

By 10 months, infants succeeded on all trials. They touched the box much less often in the course of reaching for the toy, and when they did touch the box, they continued in to retrieve the toy more often. They were much less likely to react reflexively by grasping the edge of the box or withdrawing.

### GENERAL DISCUSSION

In both Experiments 1 and 2, 7-month-old infants retrieved the toy, in all conditions where it was contiguous with the front wall of the box, except for the one condition where the higher box was 4 to 6 in. from the infant and the toy was placed horizontally behind the front wall. Moreover, 7-month-old infants failed even when the toy was not contiguous with the front wall of the box if the thinner toy was placed 0.5 in. from the front wall. Experiment 1 demonstrated that contiguity was not a sufficient condition for failure; Experiment 2 demonstrated that it is not necessary either.

In all conditions where the infants succeeded it was possible to reach on a straight line for the toy. Trials on which the infants failed were characterized by two things: (1) a two-directional reach to the toy was required, and (2) infants grazed the edge of the box en route to the toy much more often than they did in the other conditions. We think they touched the box more often because of the greater difficulty of executing a reach that changes direction. Seven-month-olds reacted to these touches, especially if their palm touched, by reflexively grasping the box or reflexively withdrawing their hand in the manner of the grasp and avoidance reactions described by Twitchell (1965, 1970).

If the 7-month-old infants had been able to guide their reaches precisely to the toy without touching the box, reflexive reactions to touch would not have been a problem on the task. Similarly, if they had been able to inhibit reflexive reactions to touch, it would not have mattered if they reached imprecisely and touched the box. When they touched the edge of the box they could have simply proceeded in and retrieved the toy. There was nothing physically blocking their way, but they reacted to the touch by grasping the box or pulling their hand back. Because 7-month-olds reacted reflexively to touch, the key to their success was whether they would reach their goal without contacting anything en route.

Alternative interpretations based on motivation, order of testing, or distance

of toy from infant are not supported by the data. The same toy was used on trials where infants succeeded as well as on trials where they failed. Infants failed when the toy was directly behind the front wall of the box both early and late in testing. The toy was farther from the infant when it was in the center of the box and closer to the infant when it was in front of the box than when it was directly behind the front wall, yet infants succeeded when the toy was in the center or in front of the box. There is also evidence that infants' depth perception is quite good by 7 months of age (Aslin & Dumais, 1980; Gordon & Yonas, 1976; Held, Birch, & Gwiazda, 1980; Walk, 1978), so an explanation based on inadequate perception of depth can be eliminated as well.

Most studies have examined the contiguous condition of the desired object placed *on top of* another object. (It was Bower [1974] who generalized this to all conditions of contiguity—on top, under, behind, or in front.) Infants of 5 to 6 months often fail to retrieve an object placed on top of another object, although by 7 to 8 months this difficulty has largely disappeared (Bresson et al., 1977; Piaget, 1954 [1937]; Wishart & Bower, 1984, 1985). We believe the problem posed for infants by the "on top of" condition is similar to that seen in the "in back of" condition studied here, that is, an inability to inhibit reflexive grasping or reflexive withdrawing upon contact with the neighboring object. At 5–6 months of age, the reach still lacks some precision and the hand is typically opened wide to grasp well before arriving at the target. Thus, 5- to 6-month-old infants are likely to touch the object bordering their goal if the goal object is slightly smaller than its support, even though the infants can reach straight to the goal without changing direction. By 7 to 8 months, the reach and the grasp have become more precise, and so infants no longer touch the neighboring object unless required to make a detour by reaching along one direction to avoid the neighbor and then changing direction to obtain the goal. At 7 to 8 months, just as at 5 to 6 months, however, if the neighboring object is accidentally touched, a reflex of the hand is released.

Although neither Piaget nor Bower considered the possibility that reflexive reactions to touch might account for infants' failure to retrieve contiguous objects, their descriptions of infants' behavior are quite consistent with this:

Laurent tries to grasp a box of matches. When he is at the point of reaching it I place it on a book; he immediately withdraws his hand, then grasps the book itself. (Piaget, 1954 [1937], p. 177). (Note the reactions described by Piaget: grasping the support or withdrawing the hand.)

Suppose a baby is shown an attractive toy and this toy is then placed on top of a platform. The baby could be in midreach for the toy. When it is placed on top of the platform, he will *pull back his hand* and look at the toy in bewilderment. He may *grasp the platform* and accidentally knock the toy off. (Bower, 1977, pp. 115–116 [emphases added])

On the other hand, infants should be able to reach their goal without touching the edge of the support if the support is smaller than the goal object or much larger, or if the goal object stands out from the support. Thus, Piaget observed:

[W]hen I place upon the book a narrow and deep goblet which stands out from its support, Laurent takes possession of it directly. But this experiment does not teach him anything about the general problem and when I place the matchbox on the book again he still does not try to grasp it. (1954 [1937], pp. 177–178).

The goblet stood far enough out from the support that it could be grasped without touching the book. Piaget also reports success at retrieving the matchbox from the tabletop, which is so much larger than the matchbox that Laurent would not touch the edge of the table while reaching for the matchbox. (Note that we would predict a problem if the matchbox were placed very near the edge of the table.)

In other work with the transparent boxes used here (Diamond, submitted), we found that 5- to 6-month-old infants were unable to retrieve an object from inside these boxes even when the object was not touching any wall of the box. They had difficulty aiming their hand so that it cleared the opening, even when the reach did *not* need to change direction and the infants were looking directly at the object through the opening. Once they touched the edge of the box opening, they reflexively grasped or reflexively withdrew their hand. Thus, they could retrieve the object if it extended partially out of the box, but not if the object were totally inside the box, even if just barely inside the opening. Similar findings in infants of 6 months with an opaque screen are reported by Schonen and Bresson (1984).

There is growing evidence, however, that younger infants of 3 to 5 months may be confused about contiguity in the way Piaget and Bower described. When two objects are contiguous and stationary, these younger infants may not perceive that these objects are distinct. For example, Kestenbaum, Termine, and Spelke (1987) familiarized 3-month-olds to a display of a small object in front of a larger object, with the two objects either contiguous or not. After habituation, the infants were shown test displays where the spatial relationship of the objects was changed or preserved. In the changed condition, the distance between the objects was increased. When the objects had not been contiguous on first presentation, infants looked equally at both test displays. When the objects had been contiguous on the first presentation, infants looked longer when the spatial relationship changed. This suggests that 3-month-old infants may have perceived the two adjacent objects as one unit and so dishabituated when these objects were shown to be separate entities. Thus, it seems that at 3 months, infants may not understand the concept of contiguity, although immaturity of the visual system may have been a factor here. Schmidt and Spelke (personal communication) are accumulating similar evidence that infants of 5 months do not perceive two objects as distinct from one another when both are stationary and one partially occludes the other, although by 7 months infants no longer make this mistake.

Finally, it is not clear why 7-month-olds who eventually succeeded in retrieving the toy from directly behind the front wall of the box in the present study often did so while they were looking up. In part, the sight of the toy through both the top and front of the box may have been confusing, especially when access through the front was blocked. In part, once an infant was grasping the edge of the box, the hand could reach the toy along a direct route without changing direction. When 7-month-old infants were attending to what they were doing, they never continued a reach once they grasped the front wall although straight access to the toy was possible from there, but instead pulled their hand back to reach again. However, when they were attending elsewhere, their hand slipped down and touched the toy as their grasp relaxed. This curious phenomenon deserves further study, as does the observation of Bresson et al. (1977) that infants first solved the problem of retrieving a small object from a slightly larger support by holding onto the support with one hand and then reaching for the goal object with the other hand.

Reaching over the front wall in order to get the toy, instead of reaching straight for the toy, can be considered a means-end behavior. Infants begin to succeed here at the same time that other means-end behaviors first appear: uncovering a hidden object (Diamond, 1985; Gratch & Landers, 1971) and pulling a cloth in order to retrieve the toy on top of it (Willatts, 1987).

Instead of infants elaborating complex rules about the existence of an object when it borders another object, we suggest that the problem is much simpler, and 7-month-olds much brighter, than Piaget and Bower have implied. By 7 months, infants understand that an object is still there when it shares a boundary with another object, but they lack sufficient control of their behavior to demonstrate this knowledge. The problem is not in understanding that the toy is there, but in navigating to reach it. Seven-month-old infants lack the finely calibrated motor skill to retrieve a small object without grazing the edge of the surface it borders, and once they graze the edge they are unable to inhibit reacting reflexively with the grasp or avoidance reaction.

Lack of inhibition may, thus, mask expression of a cognitive competence. In contrast to the usual conception of development as proceeding through the progressive acquisition of knowledge, we suggest that development can also proceed through enhanced inhibition of reactions that get in the way of demonstrating knowledge that is already present.

#### REFERENCES

- Aslin, R.N., & Dumais, S.T. (1980). Binocular vision in infants: A review and theoretical framework. *Advances in Child Development and Behavior*, 15, 53-94.
- Bower, T.G.R. (1974). *Development in infancy*. San Francisco: Freeman.
- Bower, T.G.R. (1977). *The perceptual world of the child*. Cambridge, MA: Harvard University Press.
- Bresson, F., Maury, L., Pieraut-Le Bonniec, G., & Schonen, S. de (1977). Organization and lateralization of reaching in infants: An instance of asymmetric functions in hands collaboration. *Neuropsychologia*, 15, 311-320.
- Bresson, F., & Schonen, S. de (1977). A propos de la construction de l'espace et de l'objet: La prise d'un objet sur un support. *Bulletin de Psychologie*, 30, 150-158.
- Diamond, A. (1985). Development of the ability to use recall to guide action, as indicated by infants' performance on AB. *Child Development*, 56, 868-883.
- Diamond, A. (1989). *Retrieval of an object from an open box: The development of visual-tactile control of reaching in the first year of life*. Manuscript submitted for publication.
- Gordon, F.R., & Yonas, A. (1976). Sensitivity to binocular depth information in infants. *Journal of Experimental Child Psychology*, 22, 413-422.
- Gratch, G., & Landers, W.F. (1971). Stage IV of Piaget's theory of infant's object concepts: A longitudinal study. *Child Development*, 42, 359-372.
- Held, R., Birch, E., & Gwiazda, J. (1980). Stereocuity in human infants. *Proceedings of the National Academy of Sciences, USA*, 77, 5572-5574.
- Kestenbaum, R., Termine, N., & Spelke, E.S. (1987). Perception of objects and object boundaries by three-month-old infants. *British Journal of Developmental Psychology*, 5, 367-383.
- Piaget, J. (1954). *The construction of reality in the child*. New York: Basic Books. (Original French edition, 1937).
- Schonen, S. de (1982). Données sur le développement du geste et de la représentation de l'espace. *Psychologie Française*, 273-281.
- Schonen, S. de, & Bresson, F. (1984). Développement de l'atteinte manuelle d'un objet chez l'enfant. *Comportements*, 1, 99-114.
- Twitchell, T.E. (1965). The automatic grasping responses of infants. *Neuropsychologia*, 3, 247-259.
- Twitchell, T.E. (1970). Reflex mechanisms and the development of prehension. In K. Connolly (Ed.), *Mechanisms of motor skill development* (pp. 25-45). New York: Academic Press.
- Walk, R.D. (1978). Depth perception and experience. In R.D. Walk & H.L. Pick, Jr. (Eds.), *Perception and experience* (pp. 77-103). New York: Plenum.
- Willatts, P. (1987). Development of problem-solving. In A. Slater & J.G. Bremner (Eds.), *Infant development*. Hillsdale, NJ: Erlbaum.
- Wishart, J.G., & Bower, T.G.R. (1984). Spatial relations and the object concept: A normative study. In L.P. Lipsitt & C. Rovee-Collier (Eds.), *Advances in infancy research*, 3 (pp. 57-123). Norwood, NJ: Ablex.
- Wishart, J.G., & Bower, T.G.R. (1985). A longitudinal study of the development of the object concept. *British Journal of Developmental Psychology*, 3, 243-258.