

BRIEF REPORT

Infants' Manual Exploration of Pictorial Objects Varying in Realism

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In previous research, we established that 9-month-old infants manually investigate pictured objects by hitting, rubbing, and grasping as if to pluck them off the page. This behavior suggests that infants do not understand the 2-dimensional nature of pictures. Although they can perceive depth cues and distinguish pictures from objects, they do not appreciate the significance of these cues; that is, they do not realize how depicted objects differ from real ones. We report 2 studies that support the idea that infants' manual response to pictures is driven by the resemblance of depicted objects to the real objects they represent. In Study 1, we report that infants' manual investigation of pictures is directly related to how realistic they are: The more depicted objects look like real objects, the more manual investigation they evoke. In Study 2, we show that 9-month-old infants' manual behaviors are concentrated on depicted objects even when there are areas of greater perceptual contrast on the page. The results are discussed with respect to the early development of pictorial competence.

Symbols are ubiquitous in all cultures, so one must acquire a variety of symbolic skills to function effectively in any society. Pictures are a particularly pervasive type of symbolic representation; in industrialized societies, they are found in

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books, magazines, and newspapers, on signs, art gallery walls, and computer screens, in family photo albums and displays, and so on. Because pictures are commonly used to convey information, it is important that children develop pictorial competence—the ability to recognize, interpret, use, and understand pictures (DeLoache & Burns, 1993; DeLoache, Pierroutsakos, & Troseth, 1996).

The role of experience in the development of pictorial competence has been the center of substantial debate: Theorists are divided on whether learning is required to understand pictures. On the one hand, theorists such as Gibson (1971, 1979, 1980) have asserted that realistic pictures afford much of the same visual information present in the objects themselves; therefore, one can perceive the information in pictures without prior pictorial experience. On the other hand, Goodman (1976) and Gombrich (1969, 1974) emphasized the symbolic aspect of pictures, claiming that one must learn the “language of pictures” to interpret them.

There is substantial evidence that experience is not required to perceive the information in pictures: Infants at a very young age, and thus with little or no picture experience, are capable of recognizing depicted objects, as well as discriminating them from actual objects (e.g., DeLoache, Strauss, & Maynard, 1979; Dirks & Gibson, 1977; Hochberg & Brooks, 1962). Even newborns can recognize shape depicted in a two-dimensional representation (Slater, Morison, & Rose, 1983), and they can also differentiate three-dimensional stimuli from their two-dimensional counterparts (Slater, Rose, & Morison, 1984).

Perception, recognition, and discrimination are not, however, tantamount to understanding the nature of pictures. Pictures have a “duality” (Gibson, 1979) or “double reality” (Gregory, 1970). A picture is both an object—composed of markings on a surface—and a representation of something other than itself (Ittelson, 1996). Pictorial competence involves both the perception of depicted information and the understanding of how the depiction is related to what it represents (DeLoache & Burns, 1994; DeLoache et al., 1996). It includes knowing both how a picture is similar to and how it differs from what it depicts.

Pictorial competence thus depends on the ability to achieve dual representation—one must mentally represent both the surface or content of the picture itself and what the picture stands for (DeLoache, 1995; DeLoache et al., 1996). One must simultaneously “see” the picture surface and “see through” the picture to its referent. Both perception and conception are involved. We have argued that in the development of mature pictorial competence, the conceptual understanding of what a picture is—and what it is not—lags behind the perception of pictorial information.

This claim stems from our previous research indicating that although infants can perceive the two-dimensional nature of pictures, they do not understand its significance (DeLoache, Pierroutsakos, Uttal, Rosengren, & Gottlieb, 1998); that is, they do not understand the crucial differences between depiction and reality. We presented 9-month-old infants with a book comprising highly realistic color photographs of single objects. In the initial study, every one of the infants manually investigated at least one of the pictures. They rubbed, patted, and hit at the

images and sometimes even appeared to try to pluck the depicted objects off the page. Thus, to some extent, these babies treated the depicted objects as if they were real objects. In a second study, another group of 9-month-olds behaved the same way toward pictured objects (DeLoache et al., 1998, Study 4). So did infants halfway around the world from the midwestern American children in our original study: Babies from a rural, relatively pictureless society in the Ivory Coast of Western Africa responded in the same way to pictures (DeLoache et al., 1998, Study 3). Thus, the phenomenon of manually responding to pictures is replicable and robust.

Why do 9-month-old infants respond manually to pictures? We have proposed that they manually explore the highly realistic color photographs of objects that we have used in our research precisely because these depicted objects do, to some extent, look like real objects. Their overall shape conforms to that of the objects they depict, they are similarly colored, shading and texture are apparent in the photographs, and the objects cast shadows on the background against which they are photographed. The babies attempt to respond to the depictions as if they were their referents.

This does not mean that the infants are unable to distinguish pictures from objects. When 9-month-olds were simultaneously presented with both an object and its photograph, their first reach was almost always to the object, indicating discrimination between them, as well as a strong preference for real over depicted objects (DeLoache et al., 1998, Study 2). Nevertheless, even with the real object available, the infants went on to respond manually to the depicted object about 40% of the time.

With age, manual investigation of pictures diminishes. The touching and attempted grasping that was so prevalent in 9-month-olds' response to realistic color photographs was virtually absent in the behavior of a group of 19-month-olds and relatively rare for 15-month-olds (DeLoache et al., 1998, Study 4). The older infants instead responded to pictures by pointing to and labeling the depicted objects. They had apparently learned two important lessons: the futility of trying to manipulate pictured objects and the culturally appropriate behavior toward pictures.

In the research reported here, we test two predictions derived from our view that 9-month-old infants' manual investigation stems from poor understanding about the nature of depicted objects. If young babies respond to pictures as if they might be real objects, one would expect their behavior to be influenced by the extent to which the depicted objects resemble their real counterparts. Thus, in Study 1, we examine whether 9-month-old infants' manual investigation of depicted objects depends on how realistic the depictions are. In Study 2, we compare infants' manual response to pictured objects versus areas of high contrast that do not depict an object.

STUDY 1

According to our account of infants' manual investigation of pictures, infants treat the objects depicted in pictures to a certain extent as if they were real objects

because in many ways they look like real objects. If so, the more perceptually similar a picture is to a real object, the more manual investigation it should evoke. Conversely, a picture that shares fewer of the perceptual features of the object it depicts should elicit less manual investigation. In other words, there should be a direct relation between pictorial realism (i.e., the number of features in common between picture and object) and degree of manual exploration. To test this hypothesis, we presented 9-month-old infants with pictures that varied in how realistic they were, ranging from highly realistic color photographs to black-and-white line drawings.

Method

Participants. The participants were forty-eight 9-month-old children. An additional 3 children did not complete the experimental session due to fussiness and were dropped from the study. Each child participated in one of four conditions: (a) color photographs ($n = 16$, $M = 9.1$ months, range = 8.6–9.6); (b) black-and-white photographs ($n = 8$, $M = 9.2$ months, range = 8.8–9.8); (c) color line drawings ($n = 8$, $M = 9.0$ months, range = 8.6–9.4); and (d) black-and-white line drawings ($n = 16$, $M = 9.0$ months, range = 8.7–9.5). (The data from the color photograph condition were originally reported in Study 4 of DeLoache et al., 1998, which was a replication of DeLoache et al.'s original Study 1.) In each condition half of the participants were girls, and half were boys. Gender and stimulus order were counterbalanced. In both the studies reported here, the names of potential participants were obtained from files of newspaper birth announcements, and parents were contacted by telephone. The sample was predominantly White and middle class.

Materials. Eight books, like many books for infants and like those we have used in previous studies, were constructed of cardboard pages secured by a plastic binding in the center. Each of the eight pages was 13×18 cm. The photographs were mounted on the cardboard pages and covered with clear contact paper. The depicted object always appeared in the center of the page. Half of the pictures were placed to the right of the binding and half to the left; all pictures faced a blank page that was also covered with contact paper. Only one type of picture appeared in any book. Two books were made for each picture type; the pictures were arranged in random order in one book and in the reverse order in the second book.

Four different kinds of pictures were used. Figure 1 shows an example of the four different versions of the same object, a toy car. The color photographs were eight professionally produced, highly realistic color photographs of individual objects resting on a plain gray surface (the same stimuli used in both

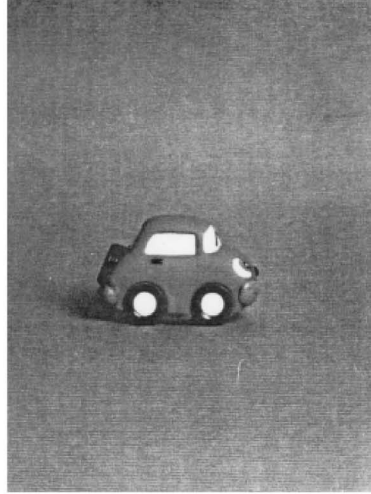
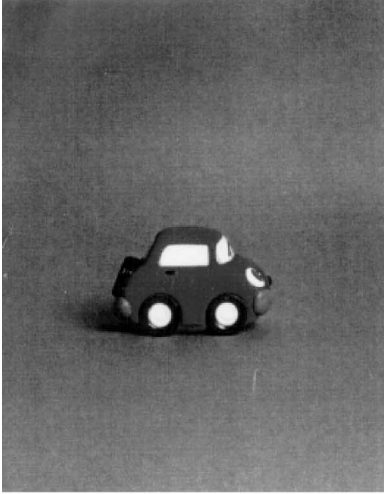


FIGURE 1 Examples of the stimuli used in Study 1: a color photograph, black-and-white photograph, color line drawing, and black-and-white line drawing of the same object. A color version of this figure can be found at <http://www.infancyarchives.com>

previous studies reported in DeLoache et al., 1998). The depicted objects were a toy car, panda bear, bottle, sippy cup, rattle, pink bear, telephone receiver, and toy keys. The shadows that the objects cast on the surface were apparent in the photographs and contributed to their realism. Black-and-white photographs were professionally printed from the color negatives. Thus, the black-and-white-photographs contained similar shadows and texture as the original photographs, but were depicted in shades of gray rather than in color. Color line drawings were made by tracing the photographs of the objects onto white paper using black ink, and then coloring them in with colored markers to match the color photographs, resulting in bright, salient depictions. The resulting pictures matched the colors of the color photographs, but the colors were generally brighter with no shadows or texture. Plain black-and-white drawings were made by tracing the original photographs with black ink on white paper. Some internal details of the objects, such as the windows of the car and the eyes of the panda, were also drawn in with ink. All of the depicted objects measured approximately 3 cm × 3 cm as in previous studies, regardless of the size of the actual objects.

To construct the stimulus books, high-quality color copies were made of all the photographs and drawings, and all the pictures were mounted on cardboard and covered with clear contact paper, giving them the same matte finish. Thus, the only differences among the four types of pictures were the elements we intentionally manipulated to vary realism.

Procedure. Each infant was seated in a high chair, and a book was placed on the tray directly in front of him or her. If the infant did not look at the book, the experimenter called attention to it by tapping on the tray above the center of the book. The infant was free to explore any part of the surface of the open pages, but we prevented other activity with the books. For example, if an infant tried to turn the pages or pick up and move the book, the experimenter gently removed it and returned it to the tray. Each of the eight pictures remained available for approximately 15 sec, after which the experimenter turned to the next picture.

Coding. Video recordings of the sessions were coded using the same relatively conservative coding criteria adopted by DeLoache and colleagues (1998) to differentiate between manual behaviors directed toward the pictures and indiscriminate hand movements. For a manual behavior to be coded, the participant had to be looking at the picture (and hence at his or her hand on the book). This criterion was used to rule out instances in which the child's hand was moving on the book while his or her attention was somewhere else. Coded behaviors had to be at least 1 sec in duration, eliminating very brief touches. Repeated behaviors were not counted separately. If an infant made several successive grasping motions while maintaining fixation on the picture, only a single grasp was

scored. This conservative guideline restricted the number of behaviors coded to the number of times the infant initiated an investigative effort. A behavior was considered to have ended when the infant looked away, initiated a different behavior (e.g., switched from hitting to grasping), changed hands, or removed the hand(s) from the picture.

Two categories of manual contact to the objects were depicted on the pages of the book were coded:¹ (a) grasping—change of hand shape or curling of the finger(s) after contacting the surface of the page; this behavior appeared to the coders to be an attempt to pick up the depicted object; (b) other deliberate investigative behavior—manual contact and active exploration of the depicted objects in the book; hitting and rubbing are the main behaviors in this category. As in previous work, a high level of reliability was found for two coders' scoring of manual investigation directed toward the pictured objects (.89).²

Results and Discussion

Figure 2 depicts the manual exploration of depicted objects by two of the participants in Study 1. Figure 3 shows the results of the study. As is clear, manual investigation was directly related to the realism of the pictures: The more the depicted objects looked like real objects, the more manual investigation they evoked.

Preliminary results indicated no main effects for gender, order, or picture position so these variables were excluded from further analyses. In a one-way analysis of variance (ANOVA) of the number of manual investigative behaviors, there was a main effect of picture type, $F(3, 44) = 4.55, p < .01$. A similar ANOVA for the number of grasping behaviors alone was also significant, $F(3, 44) = 2.92, p < .05$. Post hoc analyses revealed that color photographs evoked significantly more behaviors than black-and-white line drawings both for level of manual investigation, $F(1, 44) = 13.53, p < .01$, and grasping, $F(1, 44) = 8.53, p < .01$. Further, a two-tailed Spearman correlation confirmed a linear relationship between the level of realism of the pictures and the amount of manual investigation, $r = .439, p < .05$.

The more features the pictures had in common with the real objects (e.g., color, texture, shading, etc.), the more manual behavior they evoked. Presumably, all the features that contribute to pictorial realism influence children's tendency to investigate. Indeed, there is substantial evidence that infants are sensitive to

¹Only manual behaviors directed to the pictured objects were coded because DeLoache et al. (1998) found that almost all of infants' behavior was directed to the pictured object (vs. the background page or the blank opposite page).

²Coders, of course, were not blind to the condition of each baby, as they needed to see the depicted objects to code the behaviors directed toward them. Coders included a full-time research assistant, an advanced graduate student, and several undergraduate research assistants; thus, the level of familiarity with the hypotheses varied.

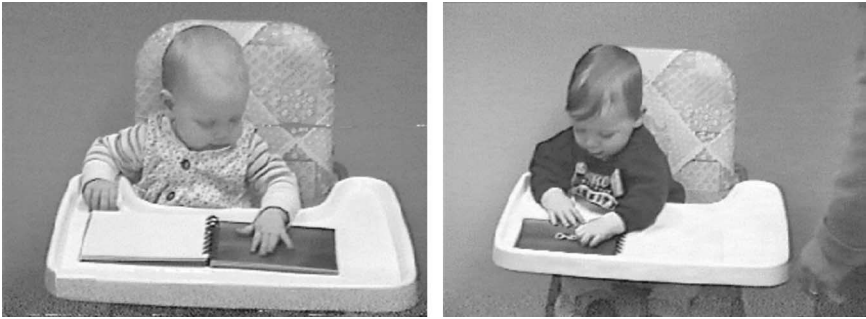


FIGURE 2 Manual exploration of depicted objects: The 9-month-old on the left is feeling the picture of a toy bear, and the infant on the right is grasping at a depicted rattle.

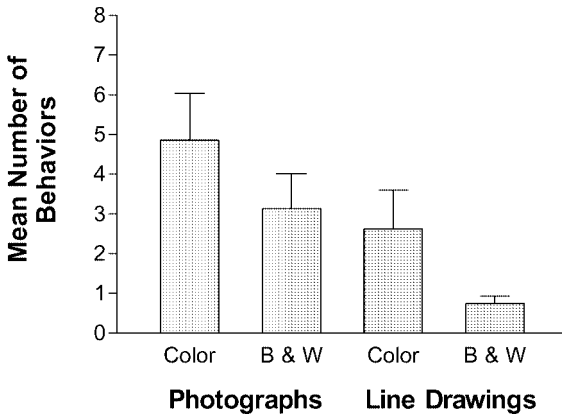


FIGURE 3 The results from Study 1: Manual investigation was linearly related to how realistic the pictures were; the more the pictures looked like real objects, the more exploration they evoked.

color (e.g., Teller, 1998; Teller & Bornstein, 1987), and shading and shadows may be particularly important (e.g., Arterberry & Yonas, 1991; Yonas, Kawaguchi, & Yang, 2001). The results of Study 1 thus support the hypothesis that in manually investigating pictured objects, infants are influenced by the resemblance of the pictorial images to the actual objects.

STUDY 2

The results of Study 1 are consistent with and lend support to our view that infants' manual investigation of depicted objects reflects exploration of entities that

in some ways look like real objects but in some ways do not. Study 2 tests an alternative explanation for 9-month-olds' tendency to respond manually to depicted objects—the possibility that they are simply responding to the visual contrast between the image on the page and the background. According to this hypothesis, any contrast, regardless of whether it is associated with a depicted object or not, should elicit manual exploration. It is well established that younger infants' visual attention is strongly influenced by contrast; when presented with visual stimuli, they look preferentially at areas of high visual contrast (e.g., Banks & Salapatek, 1981; Dodwell, Humphrey, & Muir, 1987; Haith, 1990). Perhaps the infants in Study 1 and in our previous research (DeLoache et al., 1998) were responding to areas of high contrast rather than to the depicted objects per se. If so, our view that infants respond to depicted objects primarily because of their resemblance to real objects would be undermined.

There are many reasons to doubt that the 9-month-olds observed to date were responding to contrast rather than to depicted objects. One is the pattern reported in Study 1 of the positive relation between realism and level of exploration. Another is the fact that the infants in Study 1 rarely responded manually and almost never grasped at the line drawings. Nevertheless, it seemed important to investigate this possibility directly. Accordingly, in Study 2 we compared infants' manual response to the realistic photographs used in previous research with their response to a high-contrast contour that does not depict an object. To do so, we presented infants with a book of color photographs similar to those in the original study, except that the area of highest contrast on the page was not the depicted object. Instead, each depiction appeared in the center of a dark gray oval area superimposed on a white background (see Figure 4). Thus, the highest level of contrast on the page was the edge of the surrounding dark oval, which was not a depiction. If perceptual contrast is a major factor eliciting infants' manual response to pictures, they should investigate the high-contrast gray edge more often than the lower contrast image. Alternatively, if infants' manual behavior toward pictures is a form of exploration of depicted objects, they should respond to the image more than to the high-contrast edge.

Method

Participants. The participants for Study 2 were ten 9-month-old children ($M = 9.0$ months, range = 8.2–9.5), half girls and half boys. One additional participant did not complete the experimental session due to fussiness and was dropped from the study. Gender and stimulus order were counterbalanced.

Materials. The books used in this study were very similar to those constructed for Study 1. For this study, the same eight color photographs were used.

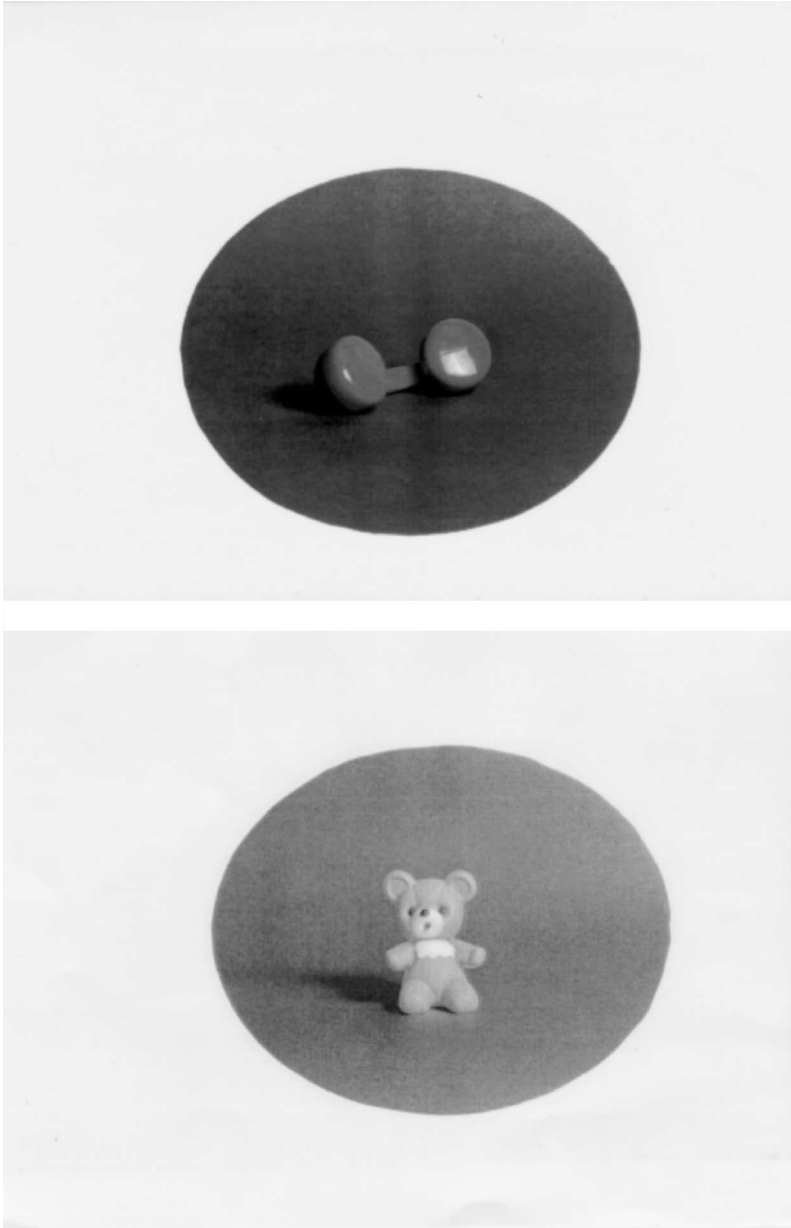


FIGURE 4 The stimuli used in Study 2: Each depicted object appeared in the center of a dark oval that contrasted with the white background around it. A color version of this figure can be found at <http://www.infancyarchives.com>

However, an oval (ca 5 cm in diameter) was cut out of the center of each photograph, resulting in a gray oval with the image of an object (approx. 2×2 cm) in its center. The gray oval was then mounted in the center of a plain white cardboard page (13×18 cm), and the cardboard pages were bound together to create a book like those used in Study 1 (see Figure 4).

Thus, each page of the book contained a depicted object against a gray background (just as in the previous studies), as well as an area of high contrast that did not depict an object. Because the level of contrast between the gray oval edge and the white background was at least as great, if not greater, as that between the edge of the depicted object and the gray background surrounding it, these stimuli made it possible to compare infants' manual response to depictions versus nonpictorial contrast.

Procedure. The procedure was the same as that in Study 1.

Coding. The coding was the same as that used in Study 1, except that behaviors were coded according to whether they were directed to the depicted object in the center of the page or to the edge of the surrounding oval. In either case, target behaviors were coded only if the infant's hand, fingers, or both made contact with the book surface either directly on or within a 0.5 cm radius around the depicted object or the oval edge.

Results and Discussion

The infants' investigative behaviors were predominantly directed toward the pictured objects. As found by DeLoache and colleagues (1998), the infants touched and grasped at the depicted objects. Overall, they responded twice as much to the objects than to the edge of the oval gray area that surrounded them. Further, infants never grasped at the oval; they grasped only at the objects in the center.

Figure 5 shows the level of manual investigation according to where on the page it was directed. Infants manually investigated the depicted object significantly more often than the high-contrast edge, $t(1, 9) = 2.86, p < .05$. (Preliminary analyses indicated no effect for order or gender.)³

These results indicate that infants' manual exploration of pictured objects is not simply due to an attraction to high contrast. If it were, the infants should have responded at least as much to the high-contrast gray contour as to the

³An additional analysis indicated that the differing numbers of participants in the three conditions did not affect the results. This analysis included only the first 8 infants tested in the color photograph and line drawing conditions.

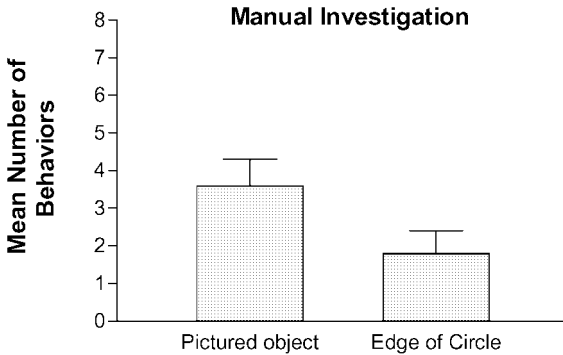


FIGURE 5 The results from Study 2: 9-month-old infants directed most of their manual investigation and all of their grasping toward the depicted object. They never grasped at the oval edge.

objects depicted within the gray area. Instead, their manual exploration, and especially their grasping efforts, were directed toward the area of the page on which an object was pictured.

Note that the level of manual exploration of depicted objects in Study 2 was somewhat lower than it was in the color photographs condition of Study 1 and that the infants did not completely ignore the gray contour. The latter might suggest that infants' manual investigation of pictures is to some extent driven by simple contrast. However, it is likely that at least some of the responses to the gray contour were clumsy attempts to touch the depicted objects. The manual behavior of the 9-month-olds in our research frequently seemed to suffer from poor aim; infants who appeared to the coder to be aiming for the depicted object sometimes ended up with their fingers on the blank part of the page (resulting, of course, in no manual behavior to the picture being coded). At the same time, some of the infants' responses to the gray oval may represent exploration of contour per se. In any event, the fact is that twice as many of the manual behaviors, and all of the grasps, involved contact with a depicted object.

The claim that the infants in this and our previous research are responding to the objects that are depicted in color photographs is vividly supported by the infant shown in Figure 6. As with most of the infants in this study, his focus was directed primarily to the depicted objects. However, he did not restrict himself to rubbing and grasping at the images. When shown the picture of the baby bottle, he first grasped at it and then leaned over and mouthed it. Although this infant's behavior suggests more commitment to the promise of the pictured object than most of the infants we have observed, responding to a depicted object as if it were a real object is very common.



FIGURE 6 A 9-month-old infant in Study 2 as he grasps and then mouths the photograph of a baby bottle. A video excerpt of this infant can be found at <http://www.infancyarchives.com>.

GENERAL DISCUSSION

In the two studies reported here, we explored the question of why 9-month-old infants manually explore pictured objects. We have shown that infants' manual behavior toward pictures is influenced by the degree of similarity between pictured objects and actual objects. In Study 1, we found that the more realistic pictures

were, the more manual exploration they evoked. The stimuli that were most often felt and grasped at were highly realistic color photographs, and the pictures that infants responded to the least were simple black-and-white drawings. We also showed that this behavior is not simply a perceptual phenomenon. The 9-month-olds in Study 2 paid little attention to an area of higher contrast that did not depict an object and instead concentrated their manual behavior on the images of objects.

The combined results thus provide support for our claim that infants' manual behavior toward pictures reflects a response to depicted objects as if they were real. We believe that 9-month-old infants' manual response to pictures is motivated by uncertainty about the nature of pictures. We know that even much younger infants can both perceive the similarity between pictures and their referents and can also discriminate between pictures and objects (e.g., DeLoache et al., 1979; Dirks & Gibson, 1977; Hochberg & Brooks, 1962; Slater et al., 1983; Slater et al., 1984). However, the current research, along with the studies reported by DeLoache and colleagues (1998), indicate that infants' understanding of the fundamental nature of pictures lags behind their ability to perceive pictorial information. They do not seem to know, as older infants do, that the depicted object they see is not tangible, that it cannot be picked up, held, felt, tasted, and so forth. Not understanding how pictures and their referents differ, infants attempt to respond to the depicted objects more or less as if they were real objects.

Their response is not, however, exactly the same as it would be to a real object. First, infants in our studies never evidence surprise at the fact that the pictured objects cannot be picked up; infants who attempt to grasp the images rarely get upset at the failure of their efforts. Even the infant shown in Figure 6 did not seem disappointed at the tasteless results of his actions, suggesting that his response to the depicted object, like that of his peers, was tentative. Second, infants contact depicted objects much less frequently than real objects (DeLoache et al., 1998, Study 2). These two aspects of infants' manual behavior to pictures support our view that this behavior is tentative—it is exploratory rather than a reflection of a true conviction that pictured objects are real.

Through experience with pictures, infants presumably learn the significance of the difference they perceive between pictures and objects; they come to understand that, no matter how much a depicted object looks like its referent, the image cannot be picked up or handled. By 19 months of age, infants have learned this fact (DeLoache et al., 1998, Study 4), and they have also learned that pictures are to be treated as objects of contemplation and conversation, not of action (DeLoache & Burns, 1994; Werner & Kaplan, 1963).

Thus, one of the earliest steps in coming to understand what pictures are is learning what they are not. Namely, infants must acquire a picture concept (DeLoache et al., 1996). This concept presumably includes features such as flat and nonmanipulable. It also signifies that part of the child's mental representation

of the depicted object does not apply to this particular stimulus; specifically, all attributes having to do with its physical reality other than its visual appearance are null in this situation. A depicted bottle cannot be grabbed or sipped from.

We believe that the 9-month-olds in these studies had not yet acquired this concept. Although they can discriminate between objects and pictures, they do not think of a depicted object as both an object and a depiction at the same time. Eventually, children come to appreciate the dual nature of pictures and to understand the various relations that can exist between depiction and reality. For example, they become capable of exploiting the information available in pictures: By the age of 2½, children can use pictures as a source of information in a retrieval task (DeLoache & Burns, 1994). At this age, they are also able to choose a picture that correctly depicts an imaginary outcome, such as a cat with milk poured on its body (Harris, Kavanaugh, & Dowson, 1997; Kavanaugh & Harris, 1994).

In conclusion, the results presented here help to clarify the role of experience in the development of pictorial competence. Experience is not required for the perception of simple pictures: Even very young infants “see through” a picture to its referent. They also “see” the flat nature of the picture, in the sense of perceiving a difference between pictures and objects, but not in the sense of understanding the significance of that difference. However, to be a mature picture viewer, one must keep in mind both the surface and the meaning behind the surface. It seems that experience is required to appreciate this duality, to “see” pictures for what they actually are, both objects in their own right and representations.

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