Journal of Experimental Psychology:
Human Perception and Performance
1991, Vol. 17, No. 2, 323–329

0096-1523/91/$3.00

Object Representation Guides Infants' Reaching in the Dark

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Infants were presented with two sounding objects of different sizes in light and dark, in which sound cued the object's identity. Reaching behavior was assessed to determine if object size influenced preparation for grasping the object. In both light and dark, infants aligned their hands when contacting the large object compared with the small object, which resulted in a reach with both hands extended for the large object and reach with one hand more extended for the small object. Infants contacted the large object more frequently on the bottom and sides rather than the top, where the sound source was located. Reaching in the dark by 6½-month-olds is not merely directed toward a sound source but rather shows preparation in relation to the object's size. These findings were interpreted as evidence that mental representation of previously seen objects can guide subsequent motor action by 6½-month-old infants.

A central issue of cognitive development is the origin of the ability to represent objects that are momentarily out of sight. This ability is a basic ingredient of adaptive actions and coherent expectations about perceived events and objects in the environment (Piaget, 1952, 1954; Spelke, 1988). According to Piaget (1954), the concept of a permanent object positioned in three-dimensional space is the product of an active construction completed by the sixth and final stage of the sensorimotor period (about 18 months of age). Prior to this stage Piaget described infants as devoid of any representational systems that provide "objectivity" to their actions. Piaget's prototypical observation is that 10-month-old infants still behave as if objects magically vanish when they are out of sight. His theoretical assumption is that infants' apprehension of an object still depends on the "here-and-now" of perception rather than on logical necessities dictated by representational systems.

Recent studies temper Piaget's interpretation of his classic and replicable observations (see the review by Harris, 1983). Instead of using Piaget's search task, which requires complex coordinated actions from the infant, new evidence has been provided that uses visual habituation techniques. Strong empirical evidence suggests that prior to 6 months of age, infant behavior is already guided by representational systems that transcend the immediacy of perception. Spelke and Kestenbaum (1986) reported that 4-month-olds understand that a continuous succession of disappearances and reappearances of a moving object from behind two spatially separated screens consists of an event involving one hidden object. By contrast, a discontinuous succession of disappearances and reappearances is understood by the infant to involve more than one object. Spelke and Kestenbaum concluded that in a condition in which one object moved behind one screen and after a pause a second object emerged from behind another screen, infants comprehended that two objects were involved in the event. By 4 months of age infants appear to comprehend the locations and movements of hidden objects in accordance with the principle that objects move on a spatiotemporally continuous path (for a review see Spelke, 1988). Through the use of a different procedure, Baillargeon (1987) reported that infants regarded objects that were out of sight as solid entities occupying space. This understanding was demonstrated by the precocious discrimination between occlusion events that are either possible or "impossible." Baillargeon (1987) presented 3- and 4-month-olds with a screen rotating back against an object or rotating back to lay flat through the place where the object had stood. Baillargeon found that infants looked markedly longer at the latter (impossible) event, which implied that the object vanished. Taken together, these observations suggest that long before infants actually search for a hidden object in the Piagetian task, they are already demonstrating some appreciation of object permanence.

The visual habituation data is based on the infant's perceptual abilities and does not require motor involvement beyond eye fixations. The Piagetian search task demands considerable coordination of perceptual and motor skills because the infant reaches to uncover an occluded object. One might hypothesize that the necessity for this complex motor response prevents the infant from revealing object permanence in the search task. Another situation that requires reaching for an unseen object, however, is reaching in the dark for sounding objects. Four studies have tested 5-to-7-month-olds (Clifton, Perris, & Bullinger, 1991; Perris & Clifton, 1988; Stack, Muir, Sherriff, & Roman, 1989; Wishart, Bower, & Dunkeld, 1978) and reported varying degrees of success with this task. Bower (1982) suggested that reaching in the dark is potentially an appropriate paradigm for assessing object permanence early in development. Supporting this idea, Perris and Clifton (1988) described the reach in the dark as accurate, with hands

This research was supported by Grant DC00362 from the National Institutes of Health and Research Scientist Award MH00332 from the National Institute of Mental Health (NIMH) to Rachel K. Clifton, by Biomedical Research Support Grant 6-32274 to Philippe Rochat, and by a predoctoral traineeship to Ruth Y. Litovsky from NIMH Grant HD07327-02. We thank Emily MacInnis, Catherine Clifton, Daniel McCall, and Amber Rimbold for helping in data collection and video scoring. We are also grateful to Catherine Clifton for suggesting the hand-placement analysis.

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open and fingers extended. This action did not require sight of either the hand or the object during the reach. Although these observations support the possibility of object permanence, they leave unresolved the issue of what guides the reaching behavior. In other words, when the infant is reaching in the dark, is the reach for the location of a sound or is the reach directed toward a sounding *object*? In the current study we address this issue.

In general, reaching is one of the earliest manifestations of a behavioral pattern that integrates different perceptual and motor systems. It implies perceptual discrimination of an object target in three-dimensional space as well as spatially oriented motor skills to guide the hand toward the object. Though infant reaching improves rapidly during the first year, evidence shows that early eye–hand coordination is not simply automatic or reflexive in nature. The reaching pattern of the young infant is not rigid but rather is adapted to the object's perceived spatial properties, such as its size (Hofsten & Ronnqvist, 1988), its orientation (Hofsten & Fazel-Zandy, 1984; Lockman, Ashmead, & Bushnell, 1984), and whether the infant perceives it as being within or out of reach (Clifton et al., 1991; Field, 1976; Yonas & Granrud, 1985). These observations suggest that at least from 6 months of age, infants' reaching resembles children's and adults' in that it is characterized by some perceptual anticipation and motor preparation.

In the present study we used both reaching in the dark and the preparatory aspect of reaching in the light to investigate further the issue of early representation in the context of object permanence. The data reported here demonstrate that by 6 months of age, infants can potentially guide their action in the dark on the basis of a stored representation of a substantial and persistent object. We presented the infants with sounding objects of various sizes in both the light and the dark, analyzing the positions of the hands and their placement on the object at the moment of first contact. We hypothesized that infants would tend to reach in the light with both hands extended for a large object and reach with one hand more extended for a small object. We assessed this tendency in the light and the possible carryover of the strategy to the dark. Our rationale was that if infants adjusted their reach in relation to the size of the object in the dark as well as the light, this suggests that their reaching is guided by a stored representation of how the object looked, sounded, and felt in the light. If infants reached similarly for both large and small objects in the dark, this suggests that they are reaching toward the sound itself or some nonspecific object making the sound.

Method

Subjects. Thirty-two infants (20 males, 12 females) ranging in age from 26 to 30 weeks ($M = 28$) completed the session. Infants were recruited from published birth announcements in the Amherst, Massachusetts, area with an explanatory letter followed by a telephone call. All infants met the following criteria, verified by a parental interview on the test day: (a) no ear infection or cold on the test day, (b) no history of chronic ear infections, (c) no suspicion of hearing loss, (d) no medication on the test day, and (e) a normal course of development following a term birth. Nine additional infants were tested but not included in the final sample because of poor state (8) and experimenter error (1).

Stimuli and apparatus. The objects were made of flexible aluminum tubing with 1.5-cm inside diameter and were covered with red, white, and blue strips of duct tape. The tubing was rounded to form a colorful ring-shaped hoop with either a 30-cm (large object) or a 5-cm (small object) inside diameter. Objects were designed to be attractive for the infant and to vary in one dimension only: their radial size.

Each circular object was attached to the end of a 1.5-m rod. A sound-producing device (either bells or a rattle) was attached to the object at the junction of the supporting rod. The sounding device was positioned immediately behind the small object and at the top of the large object, which resulted in the same spatial location for both sounds from the infant's perspective. The bell sound was produced by four jingle bells (2.6-cm diameter), and the rattle sound was produced by two plastic containers (3 × 2 cm) each containing 10 popcorn kernels. When agitated with the object to which they were attached, these devices produced highly contrasting sounds. Rhythmic shaking resulted in sound peaks from approximately 71 to 76 decibels (dB; A scale) for the bells and 66 to 73 dB(A) for the rattle, as measured by a Bruel–Kjaer sound-level meter placed at the site of the infant's head.

The apparatus consisted of a three-sided curtained frame enclosure whose front curtains opened with a drawstring to reveal an object positioned against the backdrop of a second curtain. The rod attached to the object was threaded through a hole in the backdrop and held by the experimenter from behind the curtained enclosure. The rod was supported by a camera tripod placed behind the backdrop. An aluminum trough was screwed onto the top of the tripod to support the rod and help guide the object toward the infant and maintain its position throughout the trial.

The sessions were conducted in a double-walled sound-deadened chamber connected to an antechamber that contained the video equipment and the equipment operator. Testing sessions were videotaped with two infrared cameras (Panasonic WV1800), one placed directly overhead and one placed to the right of the infant for a side view. Both camera outputs were fed through a beam splitter and a For-A date-timer into a videocassette recorder (Panasonic Model 8950) and a video monitor (Sony PVM122). An infrared light source placed 2 m directly above the infant was the only source of light during the dark trials.

Procedure. Infants were seated on their mothers' laps in front of the curtained enclosure. Parents were asked to refrain from talking and to hold the infant at the hips with both hands to provide support. Trials were initiated when the infant was quiet with attention centered straight ahead. A trial began with the curtain opening to reveal either the large or small object, which was shaken for approximately 3 s at 1.5 m away from the infant. The experimenter then pushed the rod slowly forward, keeping it centered and in alignment with the infant's shoulders. The experimenter continued to shake the object throughout the approach, which lasted about 9 s; once the object was within reach it was not advanced any further, but the rhythmic shaking that produced the sound continued until contact or for 20 s. If no grasping occurred within 20 s, the object was withdrawn, and the curtain was closed until the next trial. Dark trials were the same as light trials except that the experimenter pressed a pedal switch to turn off the room light and turn on the infrared light source prior to opening the curtain. The testing chamber was completely dark so that nothing in the surrounding environment could be seen. After 20 s in the dark or until contact was made, the experimenter turned on the lights and withdrew the object behind the curtains. Intertrial time was approximately 15 s. Throughout the testing session the experimenter received instructions by way of earphones from a second experimenter who was monitoring the video recording in an adjacent room. This guidance was especially useful in the dark condition, when the experimenter had no visual feedback as to the alignment and positioning of the object within reach and whether the infant had grasped the object.

Infants were first presented with eight trials in the light, followed by six trials in darkness interspersed with four additional light trials. Trials in the light were intended to familiarize the infants with the objects and their associated sounds; they allowed a direct comparison between reaching behavior for different-size objects in light and dark. In both light and dark, half of the trials were with the big object and half were with the small, with no more than two consecutive trials of a particular size. The type of sound was counterbalanced across subjects for the size of the object such that all four combinations were presented equally often, with order of presentation counterbalanced across the combinations.

Data scoring. The video monitor and a computer monitor were positioned at a 90° angle with a piece of plexiglass bisecting the angle. This arrangement allowed the reflection of the video image to fall on the screen of the computer monitor. While looking at this reflected video image in a frozen frame, the scorer moved a "mouse" to five positions on the screen occupied by (a) the sounding device attached to the object, (b) the back and (c) the front of the infant's head, (d) the left hand and (e) the right hand (see detailed description of the technique in the work of Page, Figuet, & Bullinger, 1989). The x and y coordinates of these positions were recorded and stored by a computer. For each subject trials were scored when either or both hands contacted the object. Trials on which the infant failed to contact the object were not scored.

The frame containing the moment of first contact was scored and analyzed. Our rationale for analyzing this particular frame was that it captures the fundamental goal of all successful reaches—contact with the object—before contact influences subsequent grasping. For this reason the moment of first contact reflects motor preparation by the shaping of the infant's arms and hands. It is the terminal part of the approach phase of the reach and thus a good descriptor of infants' anticipation of contact.

The primary measure of unimanual versus bimanual reaching was the assessment of hand alignment on the frame that showed first contact with the object. We calculated hand alignment by computing an angle (α) created by a line passed through both hands and bisected by a vertical line (see Figure 1). Through the use of the x and y coordinates of the hands stored for each analyzed frame, a program computed the value of α. A 90° α angle corresponded to perfect alignment of the hands in a bimanual reach. Angle values approaching 0° indicated that the left hand was forward in relation to the right. Angle values approaching 180° indicated that the right hand was forward. In addition to hand alignment, scorers noted the placement of each hand on the big object in terms of quadrant: top, bottom, left, and right sides.

Two independent observers scored the videotapes by using the frame-advance control device of the videodeck. Percentage agreement was 94% for identifying trials on which a contact was made and 92% for determining placement of the hand on the big object. A third independent observer settled the disagreements. Reliabilities for determination of moment of contact and α angle were assessed with Pearson product-moment correlation coefficients (r), as these measures yielded continuously distributed scores. For moment of contact $r = .94$ and for α angle at moment of contact $r = .92$ (computed on 82 trials).

Results

Manual contacts with the object were observed on 365 of 384 (95%) trials in the light and on 86 of 192 (45%) trials in the dark. Eight infants failed to reach in the dark. The proportion of trials that contained a contact, broken down by condition (big and small object, light and dark trials), is shown in Figure 2A. In both light and dark conditions, infants were equally likely to contact the big and the small object, which suggests that a successful reach for the big object in the dark was not due to the increased probability of random encounters with the larger size object. A 2 (light condition vs. dark condition) × 2 (big object vs. small object) × 2 (rattle sound vs. jingle bell sound) analysis of variance yielded a significant effect of condition, $F(1, 30) = 76.76, p < .001$. Infants reached for the object more often in the light condition ($M = .95$, $MS = .016$) than in the dark condition ($M = .45$, $MS = .065$). There were no significant interactions or main effects of object size or sound. Thus, within the light and dark conditions, neither sound nor size affected the frequency of infants' contact with the objects. Latency to contact did not differ for big and small objects in the dark ($M = 9.4$ s for the big object and 9.9 s for the small object. These comparable latencies reinforce the position that such contacts in the dark were not due to chance because the big object ought to have been touched more quickly as well as more frequently if touches were randomly distributed in space.

We assessed preparation for the grasp by comparing the spatial relationship of one hand with the other (α angle, see Figure 1) at the moment of first contact with the object. We compared preparatory reaching on all dark-trial contacts with matching light-trial contacts using the hand alignment measure (alpha angle). The matching light trials were those just preceding or following the corresponding dark trials with the same-size object. No light trial was used more than once. Sixteen infants made contact with both objects under both illumination conditions. When an infant contacted the object on more than one trial under a particular condition, the average α angle was taken as the score for that condition. Figure 2B shows the mean value of the α angle at moment of

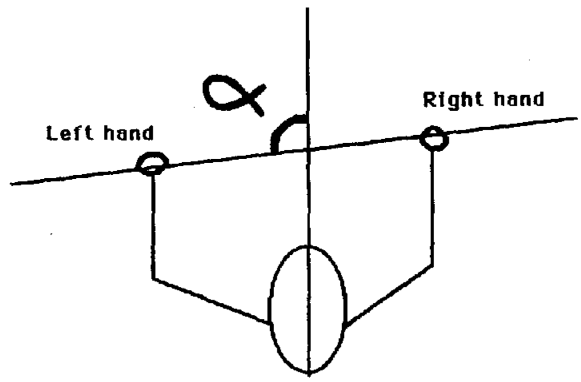

Figure 1. Assessment of hand alignment (α angle). (A 90° α angle corresponds to perfect alignment of the hands in a bimanual reach. Angle values approaching 0° indicate that the left hand is forward in relation to the right hand, whereas values approaching 180° indicate that the right hand was forward. Absolute angle differences from 90° were used to measure deviations from a bimanual reach. The vertical line to form α angle bisects the line through the hands and does not necessarily go through the head as shown in the illustration.)

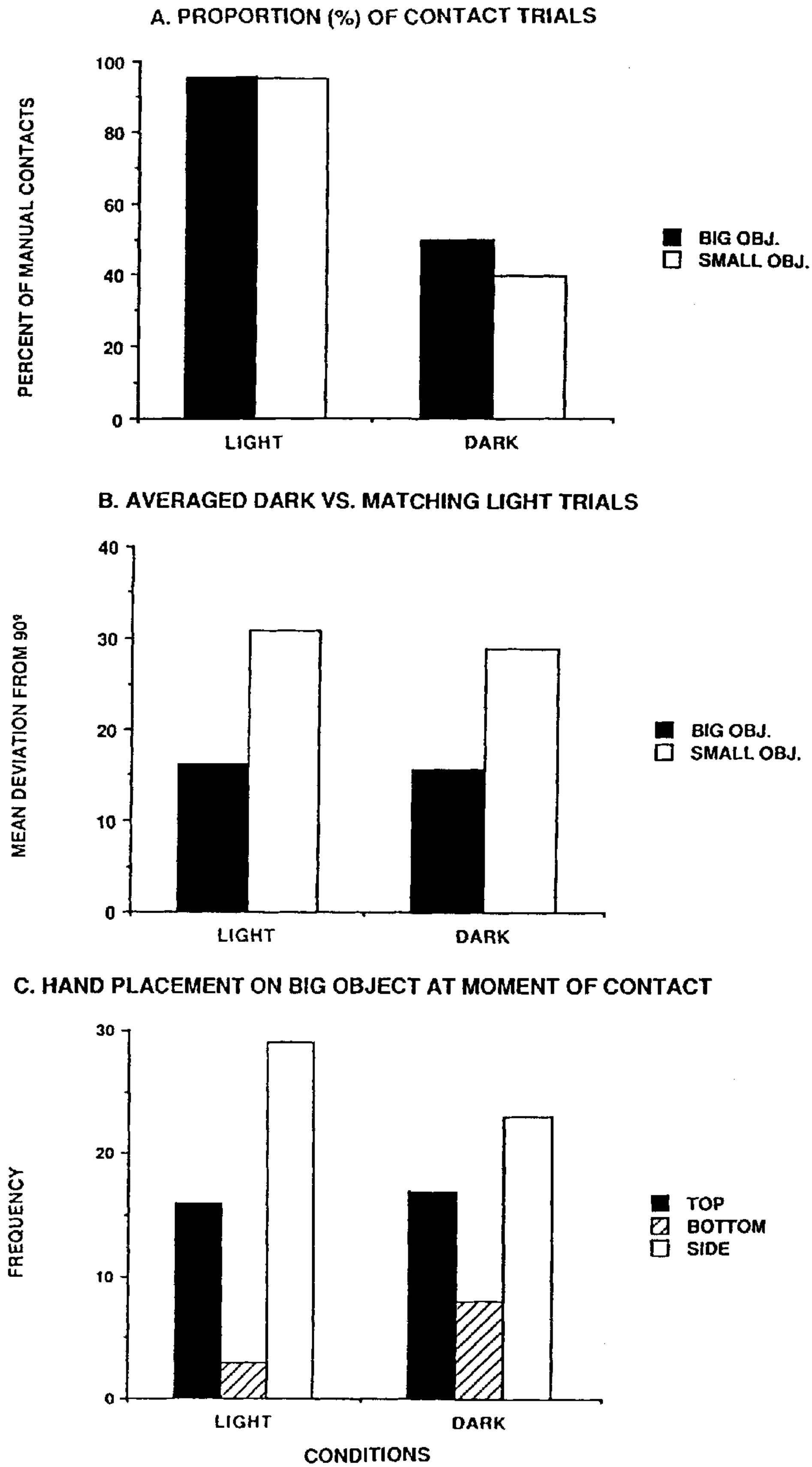

Figure 2. Differential responses to object size under varying illumination. (Panel A shows the percentage of contacts with the object over total trials for big and small objects in light and dark conditions. Panel B shows the hand alignment at first contact with the big and small objects in the dark and in matching light trials. The matching light trials were those just preceding or following the corresponding dark trials with the same-size object. The α angle shown is the mean deviation from a perfect alignment [90°] of the two hands. Panel C shows the frequency of trials on which the first contact was at the top, bottom, or sides of the big object in the light and dark.)

contact with the big or small object in the dark or in the light. Infants reached differently for the big object as opposed to the small object: object size, $F(1, 15) = 20.73$, $p < .001$; MS for big object = 4.07; MS for small object = 6.74. No effect of condition (light vs. dark) or Condition × Object interaction was found. In the dark, as well as in the light, 6½-month-olds reached with both hands more aligned for the big object and reached with one hand more forward for the small object.

Although the α angle reflects hand alignment, this angle can be influenced by the distance between the hands, so hands that are wider apart tend to result in smaller angles than when they are close together. To check on this possible bias, we correlated the α angle scores with the distance between the hands on those trials: $r = .14$, indicating an independence between these scores.

All light and dark trials were scored for the quadrant on the big object where the hand(s) first made contact. Hand placement around the circle is of interest because the small sounding device (2 × 1 cm) was attached at the top, with the major portion of the object extending away from the sound source. In the light, infants distributed their grasps of the big object around its entire perimeter. In the dark, if the infants reached in the direction of the sound source only, hand(s) placement on the big object ought to be close to the top, where the sounding device was located. Alternatively, if the infants were reaching for the object per se, the hands should not systematically make contact close to the sounding device but should grasp the object all around the perimeter (as in the light).

As in the α analysis, only the first point of contact on the big object was considered for each trial. Twenty-two infants reached for the big object in the dark for 48 trials. In this analysis for hand placement we compared the same matching light trials that were used in the α angle analysis. In both dark and light, infants distributed their grasp around all areas of the big object (see Figure 2C). In particular, the top area containing the sounding device had contacts on only 35% of dark trials, about the same proportion as in the light.

In a final analysis, we examined the possibility that the preparatory reaching observed in the dark was a conditioned motor response. The light trials served to familiarize the infant with the objects and their unique sounds. For infants to reach differentially in the dark, they presumably learned to associate a particular sound with a particular object, but this association could entail different cognitive capacities. An explanation on the basis of mental representation would claim that infants learned to associate each sound with a particular object during light trials and used this sound to identify the object in the dark. The sound was a cue for a particular object, and the infant responded with a motor pattern typically displayed in preparation for grasping an object of this size (two-handed reach vs. one-handed reach). A central feature of this view is that the infant's behavior is in response to this internal representation of the object. A contrasting explanation is that two different motor responses became linked to the sounds through conditioning in the light, and the sounds continued to elicit the same responses in the dark. This explanation carries no implication that the infant formed any mental representation of the object. In classical conditioning terms, the sight of the object during light trials is the unconditioned stimulus that elicits a motor response (unconditioned response) dependent on size. During the light trials the sound (conditioned stimulus) became associated with the sight of the object, and after four trials with each object the sound alone was able to elicit the differential response without sight of the object. If this explanation is correct, we can predict certain characteristics about the morphology of reaching behavior. If the approach to the big object is an unconditioned response, one might expect the reaches to exhibit more rigid morphology than if this were spontaneous behavior. Variability in reach might be shown across the group, as there are many ways to achieve a bimanual configuration, but each infant would be expected to have little response variability. To test this hypothesis, we analyzed hand placement on the big object at the moment of contact for the four initial trials with this object in the light. If infants tended to grasp the big object each time at the same location on its perimeter, this suggests stable motor responses that may become conditioned to a particular sound and may subsequently be executed in the dark to that sound.

For this analysis, hand placement was scored with seven categories: right hand on top, left hand on top, right hand on the bottom, left hand on the bottom, right hand on the right side, left hand on the left side, and bimanual contact. Bimanual contact corresponded to simultaneous contact of both hands anywhere on the object; it was fairly rare, because one hand usually lagged behind the other by a fraction of a second or more. (Note: There were no categories for left-hand contact on the right side and right-hand contact on the left side because such crossover is extremely rare in infants of this age.) Out of 22 infants who reached for the big object in dark and light, only 3 engaged in one category of hand placement on the big object for all four initial light trials. Although it is reasonable to speculate that these 3 infants associated the sound with this motor pattern during the initial light trials, in fact all 3 infants showed a different reaching pattern on their first dark trial. For example, one infant always initially reached in the light by grasping the right side with the right hand. On the first two dark trials, he grasped the top with his right hand, and on the third dark trial, he grasped the left side with the left hand, a placement never used in the light. Of the remaining 19 infants, 10 showed two categories of hand placement, 7 showed three categories, and 2 showed four categories. Note that although the maximum number of categories is seven, only four were possible for an infant because only four trials were available for analysis. These results indicate that the majority of infants varied their motor response to the big object even within so few trials. This variability implies that no stereotyped motor movement performed in the light was available to be implemented in the dark. A comparable look at variability of hand placement in the dark found that out of 16 infants who reached more than once in the dark, only 2 used the same hand configuration over and over.

A second analysis that considered the conditioning hypothesis was a comparison of hand placement on the big object for dark trials and matching light trials (i.e., the trials shown in Figure 2C). The conditioning hypothesis predicts a correspondence between the way a particular infant grasped the object in the light and dark, if indeed the reach in the dark was a motor pattern elicited by the sound. Out of 48 comparisons, 33 trials had hand placements from different categories, and 15 were from the same categories. Thus, infants contacted the object in different ways on 70% of light–dark comparisons, a strong case against the argument for rigid responding.

Discussion

The differential reaching behavior toward sounding objects of different sizes in the dark strongly supports the contention that 6-month-old infants have representation of objects. Depending on which sound they heard in the dark, infants adjusted their arm preparation according to the object's size. This complex and remarkable behavior has many implications concerning the young infant's perceptual and cognitive abilities. First, infants adapted their reach in the light to the object's size. This adaptation to the object's properties implies that infants came into the lab with their motor behavior already shaped by prior experience. This is not surprising in light of Hofsten and Ronnqvist's (1988) report that infants of this age adapted their hand opening to objects varying in size from 2.5 to 6.5 cm in diameter. The size difference in our objects was much greater to elicit differential arm involvement; however, both sets of results confirm the infant's ability to anticipate object properties and translate this visual information into appropriate motor behavior. This motor preparation persists in the dark, presumably on the basis of multimodal properties of the object that became associated with a particular sound during object exploration in the light. Infants were able to use one property (sound) as a clue to the object's identity in the dark.

Previous studies of infant's reaching in the dark have not ruled out that the reach was toward the sound itself, independent of the object, because objects were small and spatially coincident with the sound (Clifton et al., 1991; Perris & Clifton, 1988; Stack et al., 1989; Wishart et al., 1978). In the present study, the large diameter of the big object allowed the infant to reach away from the sound and still grasp the object. This they did, in both light and dark. By distributing their contacts around the entire perimeter of the big object, infants indicated they were reaching for an *object*, not a sound source. If sound alone guided the reach, infants ought to have grasped the object close to the sounding device. The role of sound is apparently to identify the object rather than elicit a reach to the spatial location of the sound. The need for the sound to specify a particular object may explain why infants reach with less frequency and accuracy in the dark if they have not seen and handled the object in the light, as in the work by Stack et al. (1989).

The question remains as to what exactly infants know of the object they intend to touch and grasp. Do young infants reveal any details of their cognitive representation through preparatory reaching in the dark? Because reaching anticipates the size of the object, this representation pertains, at least in part, to what the object affords for action. The morphology of the reach in the dark suggests that representation of the object's affordance for either a one- or two-handed grasp guided the reaching action. The infants were inclined to reach for the big object with both hands forward and to reach for the small object with one hand forward. These observations are in line with Gibson's (1979) theory of affordances and his assumption that the young infant primarily perceives what objects afford for action. In Gibsonian terms, the observations of preparatory reaching in the light suggest that the infant perceived the object's relative "graspability" to guide the action. The persistence of such preparatory reaching in the dark further indicates that representation plays a role in acting on the perceived affordances. In the dark, infants could not anticipate the size of the approaching object if they were using only what they heard as a guide to their reaching action. They appeared to integrate their auditory perception with visual and haptic information stored from previous experience in the light. These results point to the cognitive dimension of infant reaching in the dark and suggest that from an early age the perception of objects' affordances relies on the intermediary of representational systems.

We examined the possibility that rapid learning of a motor response in the light was simply transferred to the dark situation. The mechanism may be simple conditioning between the sound of the object and the motor movement associated with that sounding object. If this were the case, infants ought to have displayed fairly stereotyped reaches to big and small objects in the light, followed by similar responses to those objects in the dark. Neither of these results was found. On the contrary, variability in reaching activity, from trial to trial and across conditions, was the main feature of infants' behavior in this experimental situation. Proponents of conditioning might point out that response variability may be handled by differential conditioning of a general class of bimanual versus unimanual reaching patterns to the sounds. Evidence against this position was cited in Clifton et al. (1991). They presented sounding objects in the light at midline and in the dark off midline. Accurate reaching and grasping were observed in the dark, with virtually no reaches to the midline position where the object had been seen. In that study, infants appeared to rely on the sound as a cue to the new location of the object and executed a new motor response. The present study further demonstrates that infants use the sound as a cue to what the object is as well as where it is.

The observations reported here join a growing body of research claiming that from an early age infants apprehend objects as permanent and substantial entities. Contrary to Piaget's assumption (Piaget, 1954), infants as young as 4 months appear to have some representational capacities that provide objects with permanence when they momentarily disappear from sight (Baillargeon, 1987; Spelke, 1988). Mandler (1988) marshaled several lines of evidence that by 6 months or younger infants have the capacity to form, store, and recall concepts. She sought to lay to rest "the notion of the imageless infant" (p. 122). Our data lend further support to this view in that infants' preparatory reaching in the dark appears to be based on their representation of the object. Because the same reaching response is used to test object permanence in the classic Piagetian task, some explanation must be sought for why a 6-month-old will reach for an unseen object in the dark but not in the light. Bower (1982) noted that the reaching in the dark situation is different from the Piagetian task because the transition from visible to invisible object involves a disappearance into the dark of the room rather than behind an occluder. According to Bower, this transition from light to dark prevents the infant from making the search errors noted by Piaget. When the object is hidden under an occluder, the infant might confuse the boundaries of the object and occluder and thus fail to search. This confusion, rather than the lack of object permanence, was proposed to be the source of the infant's errors. Clifton et al. (1991) proposed that reaching in the dark may be easier for infants because the infant reaches directly for the desired object without having to remove an occluder or reach around a transparent barrier (Diamond, 1989). Parallel studies of infants' reaching in the dark and their search for occluded objects in the course of early development may provide important comparisons for further discussion of these issues. The present study supports the view put forward by others (Baillargeon, 1987; Baillargeon, Spelke, & Wasserman, 1985; Spelke, 1988) that very young infants exhibit some appreciation of object permanence. We further extend this view by claiming that infants use representation of the object to prepare motor activity directed toward the object.

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Received June 4, 1990
Revision received August 28, 1990
Accepted August 29, 1990 ■