Infants' Rapid Learning About Self-Propelled Objects

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Six experiments investigated 7-month-old infants' capacity to learn about the self-propelled motion of an object. After observing 1 wind-up toy animal move on its own and a second wind-up toy animal move passively by an experimenter's hand, infants looked reliably longer at the former object during a subsequent stationary test, providing evidence that infants learned and remembered the mapping of objects and their motions. In further experiments, infants learned the mapping for different animals and retained it over a 15-min delay, providing evidence that the learning is robust and infants' expectations about self-propelled motion are enduring. Further experiments suggested that infants' learning was less reliable when the self-propelled objects were novel or lacked faces, body parts, and articulated, biological motion. The findings are discussed in relation to infants' developing knowledge of object categories and capacity to learn about objects in the first year of life.

Young children face the formidable task of learning about objects and their properties. Children in both ancient and modern human societies have needed to learn which of the things they encounter are plants, which of these plants are edible and which are poisonous, and how each edible object is eaten. Similarly, children have to learn which entities are animals, and how each animal moves and behaves as predator, prey, or pet. In modern times, children have to learn the characteristic functions of the artifacts that furnish their environment. In six experiments, we be-

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gin to investigate aspects of infants' learning about one important property of many objects: the capacity for self-propelled motion.

Previous research has shed light on infants' capacities for object discrimination and categorization. By 3 to 4 months, infants can form basic-level categories, such as cats and dogs, as well as more global categories of entities such as animals and furniture, or animals and vehicles, when these objects appear in photographs (Arterberry & Bornstein, 2001; Behl-Chadha, 1996; Eimas & Quinn, 1994; Quinn, Eimas, & Rosenkrantz, 1993). By the second half-year, these categories are robust and guide infants' manipulation of objects (Mandler, 2004; Rakison & Butterworth, 1998). Nevertheless, there is no consensus concerning the features that define these categories or the cognitive processes that underlie their use by infants.

For example, 7- to 11-month-old infants have been shown to categorize manipulable, toy objects into global classes using object examination and manipulation tasks (Mandler, 2004). Because members of these categories are perceptually diverse, some researchers have suggested that infants' categorization is based on knowledge of the objects' functional or movement properties, and that knowledge of individual objects as animate or inanimate likely starts out very general, becoming more specific with experience (Mandler, 1992, 2003). Other investigators, however, have proposed more perceptually based accounts of infants' early category development, suggesting instead that infants first attend to the salient and perceptible functional parts of objects, and learn correlations that later lead to the development of conceptual knowledge (Quinn, Johnson, Mareschal, Rakison, & Younger, 2001; Rakison, 2003). According to this view, knowledge of a conceptual property such as the capacity for internally generated movement, is learned through a domain-general system that is sensitive to the correlations among features available in the perceptual array (Rakison & Poulin-Dubois, 2002). Important for this article, these two positions make different predictions about infants' early learning about objects. The former view predicts that learning might differ across conceptual domains, whereas the latter account predicts learning on the basis of correlations among perceptual features, regardless of domain.

Studies of object individuation and functional play provide suggestive evidence for the perceptual–functional distinction at the start of the second year of life. Between 10 and 12 months of age, infants begin to use information about object kinds to determine that a toy animal and a toy vehicle are distinct objects when the two objects are adjacent (Xu, Carey, & Welch, 1999) or when they appear in succession from behind a single occluder (Xu & Carey, 1996; Xu, Carey, & Quint, 2004). Importantly, 12-month-old infants fail to use salient property differences to individuate objects of the same kind (Xu et al., 2004). This contrast suggests that 1-year-old infants represent animals and vehicles as members of distinct kinds. At 14 months, infants demonstrate object-appropriate use of toy vehicles and animals in an imitation task, pretending to give a drink of water to an animal and pretending to use a key to operate a vehicle (Mandler & McDonough, 1996). Infants begin to demon-

strate appropriate functional play with familiar artifacts as early as 9 to 11 months, for example, by bringing a toy phone to the ear (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979).

Some of the most suggestive evidence for early sensitivity to the property of self-propelled motion comes from a study that introduced a new paradigm for examining young infants' causal thinking about the motions of animate and inanimate objects (Pauen & Träuble, 2004). Infants were shown two objects: a ball and a toy animal with a furry body and a face. In the first trial, the animal and ball were widely separated and remained motionless. In the next trial, the animal and ball were shown connected and moving in an irregular, self-propelled manner. In a final test trial, the animal and ball again were placed motionless in separate locations. Seven-month-old infants looked longer at the animal on Trial 3 compared to Trial 1, suggesting that, on Trial 2, they parsed the ball and the animal into two separate objects and attributed the objects' common self-propelled motion to the animal. This attribution in turn suggests that 7-month-old infants appreciate that animals, but not artifacts, can move on their own, and that they look longer at objects for which they anticipate motion.

All of the preceding studies presented infants with photographs or models of familiar objects and tested for knowledge acquired prior to the experiment, analogous to the kinds of studies generally used to assess infants' comprehension of known words (e.g., Oviatt, 1980; Tincoff & Jusczyk, 1999). Although such studies provide valuable information about the natural course of learning, they do not shed light directly on the learning process. When are infants able to learn the unique properties of objects that are important for a particular object kind? Are they able to do so after relatively limited exposure to a specific object? Does knowledge of the properties and behavior of an animate object develop gradually, over many varied learning experiences, or can it be acquired in a single session by observing a single object? Moreover, does the learning process differ for different aspects or properties of an object, such that some properties are learned more readily than others? For example, are the properties most central to an object, such as its function or manner of movement, learned more readily by infants than less relevant properties?

These questions bear on a further issue concerning the capacities that underlie children's word learning. Over the second and third years of life, children exhibit prodigious abilities to rapidly learn and remember new words, new verbally presented facts about objects, and new nonverbal object properties, even within a single session (e.g., Markman, 1989; Markson, in press; Markson & Bloom, 1997). It is less clear, however, whether the capacity for rapid learning about object properties is present in preverbal infants. If it is, then infants might learn rapidly about the properties of objects presented outside of a language context.

Here we present a series of experiments that investigate whether 7-month-old infants show rapid, enduring learning about the property of self-propelled move-

ment. We used a variant of the method developed by Pauen and Träuble (2004), because it is most similar to studies of rapid learning at older ages. Infants were presented with one wind-up toy object that moved on its own and another that was moved passively by a hand. Then they viewed both objects side by side without any motion, and their looking toward the objects was compared. If infants endowed one of the two objects with the property of self-propelled motion, and if they learned this property and remembered it at test, they were expected to look longer at that object in anticipation that it might move. This prediction is based on previous findings demonstrating that infants differentiate between self-propelled and passive motion, expect animate but not inanimate objects to move on their own, and look longer at an object that had previously done so (Leslie, 1988; Pauen & Träuble, 2004; Spelke, Phillips, &Woodward, 1995).

We first asked whether 7-month-old infants could learn that a toy animal is self-propelled (Experiments 1 and 1A). When evidence for such learning was obtained, we next asked whether this learning would endure over a brief delay (Experiment 2). Finally, we asked whether the same learning would be observed when the moving object was novel and lacked the specific features and characteristic motion of an animal (Experiments 3 and 4), and when the moving object was familiar and self-propelled but lacked the specific features and characteristic motion of an animate object: a vehicle (Experiments 5 and 6). That is, can infants rapidly learn properties of a wide range of self-propelled objects, or do they only learn rapidly about self-propelled objects that are familiar animals?

EXPERIMENT 1

Experiment 1 investigated whether 7-month-old infants can map the movement behavior of an object onto that specific object, after minimal experience, when the object has many of the features of an animal and moves in a manner that is characteristic of natural, biological motion.

Method

Participants

Sixteen full-term 7-month-old infants (8 girls, 8 boys) participated in the study. Infants ranged in age from 6 months, 23 days to 7 months, 23 days ($M = 7$ months, 4 days). Infants were recruited through mailings and subsequent telephone invitations to visit the laboratory. Parents received $5 to reimburse their travel expenses and infants received a small gift. Six additional infants visited the lab but were not included in the final sample because of failure to complete the study due to infant fussiness, parental interference, or experimenter error.

Materials

Four wind-up toy animals were used in the study: a bear, a lion, a rabbit, and a gerbil. The bear (beige) and lion (yellow) were made of plastic, were approximately 2×4 in. in size, and had moveable parts such as a mouth that opened, a head that bobbed up and down, and legs that moved in an appropriate locomotor pattern. The rabbit (white) and gerbil (brown) were furry, were approximately 3×3 in. in size, had one moving part (plastic feet that moved up and down), and had one distinctive feature (rabbit: large ears and fluffy tail; gerbil: long tail). Plastic animals (bear, lion) entered from the side of the stage corresponding to the infants' right and moved to the left, and furry animals (rabbit, gerbil) entered from the left side and moved toward the right. The toy animals were yoked into pairs (bear–rabbit, and lion–gerbil[1]), so as to maximize their discriminability: The two animals in a pair differed in texture, color, overall shape, and parts. The bear and lion made a mechanical sound as they moved, and the rabbit and gerbil made a clicking sound as they moved. The two animal pairs are shown in panel A of Figure 1.

Apparatus

The experiment was presented on a three-sided stage with a screen that could be raised to reveal and lowered to conceal the stage and any objects placed on it. The sides of the stage and the screen were white, and the floor was lined with purple foam padding to provide a contrast for the stimuli and to reduce their noise during movement. A white curtain hung over the front part of the stage to highlight the stimuli and to conceal the experimenter located behind the stage. A small video camera hidden beneath the stage recorded each infant's face throughout the study. A small TV monitor behind the stage allowed the experimenter to check that the infant was attentive before starting a trial. A second video camera located behind the infant recorded the events onstage. Both cameras fed video signals to an adjacent room where they were recorded onto videotape for subsequent offline coding on a large monitor. The stage was illuminated by a lamp that was located directly above it and by ceiling lights in the area in front of the stage; otherwise the room was dark. Classical music was played from a tape recorder behind the stage.

Design

All infants participated in two experimental blocks, with each block consisting of 6 familiarization trials and 2 test trials with one of two animal pairs (bear–rabbit

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[1]Four infants saw a cow and a chick instead of the lion and gerbil. The cow was made of plastic and had moving parts similar to the lion, and the chick was furry and had a small plastic mouth similar to the gerbil. Due to irreparable malfunctions of the cow early in the study, the pair was exchanged for the remaining 12 infants tested. An item analysis found no difference based on which of the two pairs was used ($p > .05$).

(A)

(B)

(C)

(D)
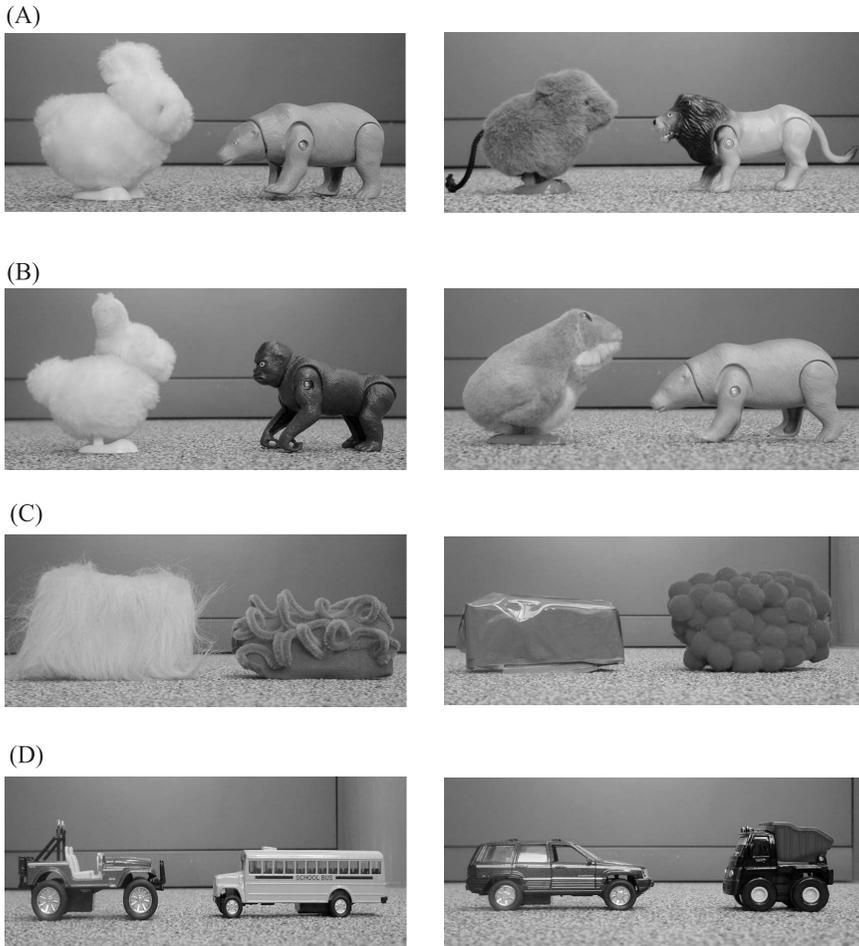
FIGURE 1   The object pairs used in (A) Experiment 1, (B) Experiment 2, (C) Experiments 3 and 4, and (D) Experiments 5 and 6.

or lion–gerbil), for a total of 12 familiarization trials and 4 test trials per infant. On alternating familiarization trials, one animal exhibited movement that was self-propelled (SP) and the other exhibited movement that was hand-generated (HG), with the order of presentation of SP and HG trials counterbalanced across infants. Every animal served as the SP object for half of the infants and as the HG object for the other half, with the order of presentation of the toy animal pairs counterbalanced across infants. All aspects of the presentation were counterbalanced across blocks for each infant (i.e., presentation order of movement type, di-

rection of movement, and type of animal on first familiarization trial, material of SP vs. HG animal), resulting in a fully counterbalanced design.

Procedure

Infants sat on a parent's lap facing a stage 3 ft away. Parents were instructed to refrain from talking to their infant or influencing his or her behavior during the study. Prior to the familiarization trials, a calibration trial was conducted to record each infant's looking behavior. A squeaky toy was used to draw the infant's attention to the right, left, center, top, and bottom of the stage, while the experimenter announced the corresponding locations. The calibration trial was recorded on videotape for observers to view prior to coding infant's looking on familiarization and test trials. The experimenter stood behind the stage during the experiment, with only her hands visible to the infant.

Familiarization trials.   Within each block, each infant received six familiarization trials: three SP trials and three HG trials. Every trial began with the screen rising to reveal a toy animal on one side of the stage, held from the top by a hand. From that point on the two types of trials differed based on the type of movement being exhibited (see later). The two types of trials were presented alternately for a total of six trials. Half of the children watched an SP trial first, and half watched an HG trial first. Each infant's total looking time for each trial was recorded on videotape. Looking time was calculated from the time the screen was raised until it was lowered.

SP trials.   After the screen went up, the hand released the animal, and it moved across the stage for 8 sec. As the animal moved on its own across the stage, the experimenter's hand remained motionless with the palm down on the side of the stage. At the end of the movement period, the hand grasped the top of the animal's back, arresting its motion, and remained there for 4 sec until the screen was lowered to conceal the stage. On SP trials, therefore, the animal moved whenever the hand released it and was stationary whenever the hand held it.

HG trials.   After the screen was raised, the experimenter's hand moved the animal across the stage for 8 sec. The hand-generated movement of the animal mimicked that of the self-propelled animal as closely as possible. Thus, on trials in which a plastic animal (e.g., the bear) was the SP animal, the rabbit was moved in a slower, walking fashion. In contrast, on trials in which a furry animal (e.g., the rabbit) was the SP animal, the bear was moved in a more rapid, hopping fashion. At the end of this movement period, the hand released the animal and it remained motionless for 4 sec until the screen was lowered to conceal the stage. While the animal stood motionless, the experimenter's hand rested with the palm down on the stage next to the animal. On HG trials, therefore, the animal moved whenever the hand held it and remained stationary whenever the hand released it.

Test trials.   Two test trials followed each familiarization phase. On the test trials, the screen was raised to reveal the two animals shown in the immediately preceding familiarization trials, positioned on opposite sides of the stage approximately 22 in. apart with the experimenter holding one object in each hand and gently grasping the top of each animal. The experimenter simultaneously released the two animals and then removed her hands from the stage area. Both of the animals remained motionless when released. A second experimenter operated a stopwatch and started timing for 30 sec from the instant the first experimenter released her hands from the animals. The screen was lowered at the end of the trial. Immediately following the first test trial, a second test trial in which the lateral positions of the two animals were reversed was administered. On completion of the test trials for the first block, the familiarization trials for the second block—using the second pair of objects—began.

Dependent Measures and Coding

Infants' looking time for both the familiarization and test trials was recorded from the time the screen was raised until it was lowered. The total amount of time that infants spent looking at the display during each of the 12 second familiarization trials was coded offline by two independent observers. Each infant's mean looking times at the display during the SP and the HG familiarization trials were computed separately. Two different independent observers, blind to both the lateral position of the animals and the pairings of animals to motion in familiarization, coded the total amount of time infants spent looking at the display during the 30-sec test trials. Each infant's total looking time toward each animal during the test trials in each block was calculated.

Coder reliability was determined by comparing the two coders' scores. Interobserver reliability was calculated as the proportion of trials on which the secondary coder's looking time was within 10% of the primary coder's looking time. The average initial interobserver reliability for Experiment 1 was 95%. If the observers' scores differed by more than 10% on a trial after independent coding, each observer recoded the trial. If the two scores still differed significantly the two observers watched the trial together discussing the infants' looking behavior, and each coder once again recoded the trial until consensus was reached.

Results

Familiarization Trials

Each infant's looking time across SP familiarization trials and HG familiarization trials was analyzed by a repeated measures analysis of variance (ANOVA) with movement type (SG, HG) and block (1, 2) as within-subjects factors. This analysis revealed no significant effect of movement type, $F(1, 15) = 2.15$, $p = .16$.

There was also no significant effect of block or a Movement Type × Block interaction. On average, infants looked equally long at SP trials (M_{SP} = 10.91 sec, SD = 1.4) and HG trials (M_{HG} = 10.36 sec, SD = 1.64). Thus, infants received equal amounts of exposure to the SP and HG animals during familiarization, and they showed no preference for either animal or movement type.

Test Trials

Panel A of Figure 2 (animals) presents the total looking time to each of the objects over the two test trials, collapsed across blocks. Because preliminary analyses revealed no effects of SP material (plastic, furry), movement type of the first familiarization object (SP, HG), or presentation side of the SP object on the first test trial compared to familiarization trials (same, different), subsequent analyses collapsed across all of these dimensions. A repeated measures ANOVA with movement type (SP, HG) and block as within-subjects variables revealed a significant main effect of movement, $F(1, 15) = 15.81$, $p < .001$, $d = 1.09$, and no effect of block or interaction between movement type and block. Infants looked longer in the test trials at the animal that was self-propelled during familiarization (M_{SP} = 16.04 sec, SD = 4.33; M_{HG} = 11.51 sec, SD = 3.98). Thirteen out of 16 infants looked longer at the SP animal during test trials.

Discussion

After brief experience with a self-propelled toy animal and a hand-moved toy animal, 7-month-old infants looked significantly longer at the stationary animal that had previously moved on its own. Because the pairing of movement conditions and animal features were counterbalanced, and because the infants looked equally at the two animals during familiarization, this preference for the self-propelled object can only be attributed to the different events viewed during familiarization.

These findings suggest that infants learned something about the motion properties of one or both objects, but an alternative interpretation may be offered. During the familiarization period, the self-propelled object made a mechanical noise, whereas the hand-moved object did not. Before concluding that infants' test-trial preference depended on the objects' different motion patterns, therefore, it is important to investigate whether the preference would be obtained in the absence of any difference in the sounds that accompanied the object motions. Accordingly, Experiment 1A was conducted.

EXPERIMENT 1A

Experiment 1A presented infants with the same objects and events as Experiment 1, with one modification: During the HG familiarization trials, the mechanical
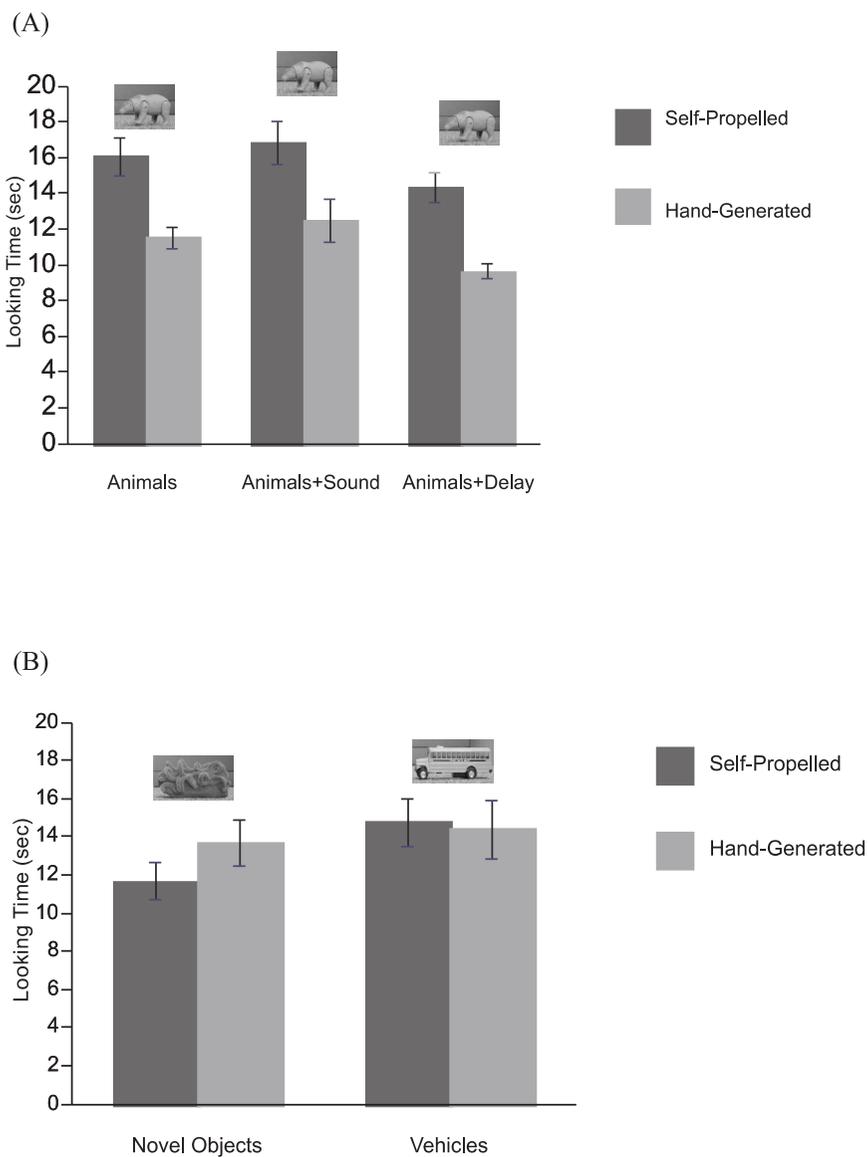
FIGURE 2 Test-trial looking times toward the object that exhibited self-propelled motion during the familiarization trials, collapsed across blocks, in (A) Experiment 1 (animals), Experiment 1A (animals + noise), and Experiment 2 (animals + delay); and (B) Experiment 3 (novel objects) and Experiment 5 (vehicles).

sound of the SP object was played for as long as the HG object was in motion. Infants therefore viewed SP and HG objects accompanied by the same sounds. If test trial preferences in Experiment 1 depended on the objects' differing sounds, no such preferences should be observed in Experiment 1A. If test trial preferences in Experiment 1 depended on the objects' differing motions, then infants in Experiment 1A should look longer at the SP object during the test trials.

Method

The method was the same as Experiment 1, except as follows. The participants were 12 7-month-old infants with a mean age of 7 months, 5 days (range = 6 months, 16 days–7 months, 19 days). The apparatus, events, design, and procedure were identical to those of Experiment 1, with three exceptions. First, the mechanical noise that naturally occurred during the movement on the SP trials was also made to occur during the movement on the HG trials. On HG trials, the noise was produced by a wind-up toy animal immediately behind the stage outside of the infant's view. Second, a yellow, furry chick was used instead of the white, furry rabbit, but was eventually replaced by the rabbit for 6 participants due to malfunction of the chick toy. Third, the data from the familiarization trials could not be analyzed because of an error in the video recording procedure.

Results

Panel A of Figure 2 (animals + sound) presents the total looking time to each of the objects over the two test trials, collapsed across blocks. Test trial looking times were analyzed by a repeated measures ANOVA with movement type (SP, HG) and block (1, 2) as within-subjectS factors. The analysis indicated a significant main effect of movement type, $F(1, 11) = 10.94$, $p < .007$, $d = 1.04$, and no other effects. Infants looked reliably longer during test at the animal that was self-propelled during familiarization ($M_{SP} = 16.81$ sec, $SD = 4.13$; $M_{HG} = 12.49$ sec, $SD = 4.15$). Ten out of 12 infants looked longer at the animal that had moved on its own during the familiarization period.

Discussion

Experiment 1A replicates the findings from Experiment 1. Even though the self-propelled and hand-moved objects were accompanied by the same noises during the familiarization trials, infants looked longer at the self-propelled object during the test. Together, Experiments 1 and 1A provide clear evidence that infants' test trial looking depended on the motion patterns of the events in which the objects were previously encountered. Infants learned about these motion patterns after only three brief exposures to each object's motion. In the next study, we began

to investigate how robust and enduring this learning is. We tested whether the same effect would occur with different animals and would survive a brief delay.

EXPERIMENT 2

Infants were presented with two new pairs of wind-up toy animals, one pair of animals in each of two blocks. As in Experiment 1, infants were familiarized with one self-propelled and one hand-moved animal, immediately followed by two stationary test trials. As in Experiments 1 and 1A, following Block 1 infants were familiarized with a second pair of animals, one self-propelled and one hand-moved. Prior to the Block 2 test trials, however, infants were taken out of the testing room for a 15-min play break in a different environment. Infants then returned to the testing room for the second set of test trials (Block 2 test). If watching a self-propelled object only engenders a fleeting preference for that object, infants should show no differential responding between the two animals during the test trials following the 15-min delay. In contrast, if infants develop more enduring representations of the motion properties of the objects, they should look longer at the object that previously moved on its own, on both the immediate and the delayed test.

Method

Sixteen full-term 7-month-old infants (10 girls, 6 boys) participated in the second study. Infants ranged in age from 7 months, 2 days to 7 months, 28 days ($M = 7$ months, 15 days). Four additional infants were excluded because of infant fussiness, parental interference, or experimenter error.

Four wind-up toy animals were used, two from the first study (the bear and rabbit), and two new ones (a monkey and a frog). The monkey was plastic, dark brown, and had movable parts similar to the bear. The frog was green, with a white belly and bulging eyes. Two new yoked pairs (comprised of two new and two old animals) were used in the second study: bear–frog and monkey–rabbit. The new animal pairs are presented in panel B of Figure 1.

The procedure was identical to the previous studies with the following exceptions. First, the length of the test trials was shortened by 10 sec, because observation of infants' test trial looking patterns showed that most infants lost interest in the stationary animals after 20 sec, and thus rarely looked at the display during the last 10 sec of each test trial. Second, and critical to the study, after each infant completed the first block of the study (six familiarization trials and two test trials) and then watched the six familiarization trials of the second block (but did not receive the test trials), the infant and parent were escorted from the testing room to a different room for a 15-min play break. After the break, the infant returned to the testing room for the Block 2 test trials. Prior to the test trials, infants received a reminder

trial, which consisted of one SP and one HG familiarization trial using the Block 1 animals. Following the reminder trials, infants received two test trials using the Block 2 pair of animals that they had been familiarized with immediately before the break. The lateral positions of the two animals were reversed across the two test trials, as in Experiment 1. Because the animal pairs differed across the two blocks and the animal that served as the SP animal in Block 2 was more similar to the animal that served as the HG animal in Block 1, the reminder trial could not serve to provide additional task-relevant information about the self-propelled object. The average interrater reliability, calculated in the same way as described in Experiment 1, was 92%.

Results

Familiarization Trials

Each infant's looking time across SP familiarization trials and HG familiarization trials was analyzed by a repeated measures ANOVA with movement type (SG, HG) and block (1, 2) as within-subjects factors. This analysis revealed no significant effects, although the effect of movement type approached significance, $F(1, 15) = 3.44$, $p = .08$, $d = .44$. Infants looked longer on the SP trials ($M_{SP} = 11.01$ sec, $SD = 1.16$) than on the HG trials ($M_{HG} = 10.49$ sec, $SD = 1.18$), but the difference was small and not reliable. Thus, infants received nearly equal amounts of exposure to the SP and HG animals during familiarization, and they showed no reliable preference for either animal or movement type.

Test Trials

Panel A of Figure 2 (animals + delay) presents the total looking time to each of the objects over the two test trials, collapsed across blocks. A repeated measures ANOVA with movement type (SP, HG) and block as within-subjects variables revealed a significant main effect of movement type, $F(1, 15) = 32.70$, $p < .001$, $d = 1.9$. There was no significant effect of block and no interaction between movement type and block. Because the two blocks were different in this study, with Block 1 representing the immediate test and Block 2 representing the delayed test, separate paired-sample t tests were conducted for each block. Infants looked longer at the animal that was self-propelled during familiarization both when tested immediately (Block 1), $t(15) = 2.69$, $p < .02$ ($M_{SP} = 14.61$ sec, $SD = 4.38$; $M_{HG} = 9.63$ sec, $SD = 3.98$), and when tested after a delay (Block 2), $t(15) = 2.29$, $p < .04$ ($M_{SP} = 13.98$ sec, $SD = 5.27$; $M_{HG} = 9.63$ sec, SD = 3.74). Thirteen out of 16 infants showed this effect when testing occurred immediately after familiarization, 12 out of 16 infants demonstrated this effect when testing followed a 15-min delay, and 15 out of 16 infants showed this effect overall when the two blocks were collapsed.

Discussion

Experiment 2 replicates and extends the findings of Experiment 1. Infants rapidly learned the movement behavior for a new set of toy animals, increasing the generality of the effect obtained in Experiments 1 and 1A. More important, infants exhibited this learning after a delay of 15 min. The latter finding indicates that infants develop more than a fleeting preference for a self-propelled object. Rather, infants appear to develop more enduring representations of an animal's propensity for self-generated movement.

Because both the self-propelled and the hand-moved object had the features of animals in these experiments, the presence of animal features such as a face and body parts evidently were not sufficient, in and of themselves, to signal to infants which object moved on its own. Nevertheless, it is possible that these features were necessary for infants' learning about self-propelled objects: In the absence of information about a face or body of an animal, infants may not learn about the object's self-propelled motion. Alternatively, animal features may not be necessary for such learning; infants may learn about the movement behavior of any self-propelled object, whether it is familiar or novel, living or nonliving, and whether it engages in biological or nonbiological motion. The next experiment begins to distinguish among these possibilities by testing infants' learning about self-propelled objects that undergo the same displacement as the wind-up animals but that lack the distinguishing properties of animals: faces, body parts, and jointed biological motion.

EXPERIMENT 3

Infants were familiarized with two novel objects, one pair in each of two blocks, following the method and procedure of Experiment 1. To create these objects, the four plastic animals used in the first three studies were disguised by covering them with different artificial materials. The novel objects thus moved in the same manner as the toy animals, but their faces, features, and moving parts were not visible to infants. After familiarization, infants received two 20-sec stationary test trials as in Experiment 2. If infants can learn about novel objects after minimal experience, then they should look longer at the test object that previously moved on its own. In contrast, if infants can only rapidly learn about the self-propelled motion of familiar animate objects, then they should exhibit no learning in this study.

Method

Sixteen full-term 7-month-old infants (9 girls, 7 boys) participated in the study. Infants ranged in age from 6 months, 28 days to 7 months, 30 days (M = 7 months, 17

days). Four additional infants were excluded from the analysis due to fussiness, parental interference, or error in the experimental procedure.

Four differently colored, uniquely textured, wind-up novel objects were used in the study: a pink object made of felt and curly pipe-cleaners; a blue object made of smooth, shiny plastic; a red object made of fuzzy balls; and a green object made of artificial fur. Novel objects were constructed from the plastic animals used in the previous two studies, and were thus slightly larger than them, measuring approximately 4.5 × 3 in. in size. The objects were yoked into two pairs based on appearance, such that the two objects in a pair differed in texture, shape, and color to the greatest degree possible (blue–red and pink–green). The blue and red objects were always presented together in one block, and the pink and green objects were always presented together in the other block. Because the four objects were motored by the plastic animals, they emitted the same mechanical sounds and motions as in the previous three studies. The self-propelled object always started on the infant's right and moved to the left, whereas the hand-moved object always started on the infant's left and moved to the right. Because all body parts were obscured, however, the motions did not appear to be biological but rather a semirigid, jumpy movement. Every infant saw both pairs of objects, one pair in each of the two blocks. The four novel objects are shown, in yoked pairs, in panel C of Figure 1.

The procedure was identical to Experiment 1 except that test trials were 20 sec in duration, and the SP object always started on the infant's right and moved to the left. This was necessary to keep the knob hidden from infants' view and still have the object move in the right direction. The HG object thus always started on the infant's left and moved to the right. Infants' looking times were coded and analyzed as in the previous experiments, with an average interobserver reliability of 96%.

Results

Familiarization Trials

Each infant's looking time across SP familiarization trials and HG familiarization trials was analyzed by a repeated measures ANOVA with movement type (SG, HG) and block (1, 2) as within-subjects factors. This analysis revealed a significant main effect of movement type, $F(1, 15) = 9.57$, $p < .007$, $d = .8$. Infants looked longer on average during SP trials than during HG trials ($M_{SP} = 11.20$ sec, $SD = 1.15$; $M_{HG} = 10.11$ sec, $SD = 1.57$), indicating a preference to look at the novel object that moved on its own during familiarization. There was no significant effect of block or an interaction between movement type and block.

Test Trials

Panel B of Figure 2 (novel objects) presents the total looking time to each of the objects over the two test trials, collapsed across blocks. A repeated measures

ANOVA with movement type (SP, HG) and block as within-subjects factors indicated no significant main effect of movement, $F(1, 15) = 1.3$, $p = .27$. There was, however, a significant main effect of block, $F(1, 15) = 5.46$, $p < .04$, $d = .5$. Infants looked cumulatively longer at the two novel objects in the first block (M_{block1} = 26.80 sec, $SD = 5.41$) compared to the second block ($M_{block\ 2} = 23.83$ sec, $SD = 6.45$). Six out of 16 infants looked longer at the SP animal during test trials.

A further analysis compared infants' learning about the motion behavior of an object when the stimuli were animals compared to novel objects. Data from Experiment 2 were used in this comparison because test trial duration (20 sec) was equal across the two studies. A repeated measures ANOVA with movement (SP, HG) as a within-subjects variable and stimuli type (animals, novel objects) as a between-subject variable revealed a significant Movement × Stimuli interaction, $F(1, 30) = 11.85$, $p = .002$, $d = 1.24$, and no other effects.

Discussion

Infants showed no evidence of rapid learning about the movement behavior of self-propelled objects that lacked the features of animals. In contrast to Experiments 1, 1A, and 2, infants showed no preferential looking at test for the object that had exhibited self-propelled movement during familiarization. Importantly, infants' overall looking time at the novel objects when they were stationary at test was no different than their looking time at the stationary animals in Experiment 2, indicating that their failure to look preferentially at the SP nonsense object did not stem from a general lack of interest. Because this study presented the same extent of motion, tested infants from the same age group and from the same population, and used the same method as the other experiments, its differing findings evidently stemmed from differences between the objects: the use of familiar animals in Experiments 1, 1A, and 2 and of unfamiliar objects lacking animal features and biological motion patterns in Experiment 3.

Infants' failure to learn the movement behavior of the inanimate objects in this study addresses a potential confound concerning differences in the way the hands interacted with the objects on the HG and SP familiarization trials of Experiments 1, 1A, and 2. Differences were controlled to the greatest extent possible by having the hand remain on the stage in both types of trials, but they could not be equated completely, because differences in the hand's behavior were crucial to distinguishing the HG from the SP motion. Experiment 3 serves as an internal control that rules out the possibility that differences in the way the hands interacted with the objects were responsible for infants' learning in Experiments 1, 1A, and 2. The hand behaved identically in Experiments 1, 1A, and 2 (which presented animals) and in Experiment 3 (which presented nonsense objects), however, infants showed a reliable preference for the SP object only in the experiments with animals. Because differences in the hand's behavior cannot account for the differing effects

across experiments, we can conclude that infants' learning depended on the objects and their motions, not the different behavior of the hands on the objects.

Although infants in the previous studies looked equally at the SP and the HG familiarization trials, those in this study looked longer at the SP compared to the HG familiarization trials. The fact that infants showed greater interest in an unfamiliar object when it moved on its own suggests that they may have been surprised to see an inanimate-looking object undergoing self-propelled motion. In addition, this observation suggests that—on some level—infants were able to discriminate between the two motion patterns of the objects. Whereas infants may have noticed a difference in the movement behavior of the two objects, this information may have been forgotten or simply not marked as relevant, and thus did not foster an expectation or preference toward one of the objects during test.

Nevertheless, two alternative explanations may be offered for infants' failure to prefer the SP novel object during the stationary test. First, because infants looked longer at that object during the familiarization period, it is possible that they were more habituated to that object and that the resulting preference for the less familiar HG object counteracted the preference they would otherwise show for the SP object. This is unlikely, because infants in this study were exposed to each object during only three brief familiarization trials. Regardless, we tested for this possibility in a number of ways. We first categorized infants in this experiment into two groups: those who showed a preference toward the SP object at test (SP preference; 6 infants) and those who showed a preference for the HG object at test (HG preference; 10 infants). We would expect to see longer looking at the SP object during familiarization for HG preference infants, if the preceding account is correct. We conducted an independent samples t test comparing the looking times of those infants who preferred to look at the HG object at test to those who preferred to look at the SP object at test. The t test compared the looking behavior of these two groups of infants toward the SP object during the familiarization trials, which revealed no significant difference between the two groups, $t(14) = .59$, $p = .56$ ($M_{SP \text{ preference}} = 11.33$ sec, $SD = 1.35$; $M_{HG \text{ preference}} = 10.98$ sec, $SD = .83$). A second analysis looked at the data from Experiment 1 and did the inverse comparison. We again categorized infants into two groups: those who preferred the SP object (10) versus those who preferred the HG object (6) during familiarization. If the preceding habituation account is correct, HG preference infants should show a preference for the SP object during test trials compared to SP preference infants. An independent samples t test revealed no significant difference between the two groups, $t(14) = .045$, $p = .97$ ($M_{SP \text{ preference}} = 16.08$ sec, $SD = 4.91$; $M_{HG \text{ preference}} = 15.97$ sec, SD = 3.59). These additional analyses should alleviate any concern that the lack of a preference for the SP object at test is best explained by habituation to the SP object during familiarization.

A second alternative explanation for the negative findings of Experiment 3 is that infants were unable to remember the two objects presented during familiariza-

tion or to discriminate between them. Although infants in past experiments have been shown to discriminate and remember novel objects that differ in form and color (Baldwin, Markman, & Melartin, 1993), the infants may have failed to do so with these objects and displays. Experiment 4 tested the latter possibility.

EXPERIMENT 4

Experiment 4 tested infants' discrimination of and immediate memory for the novel objects used in Experiment 3. During familiarization, infants saw two identical versions of one of the novel objects from Experiment 3 (e.g., two pink felt blobs) side by side on the stage with no motion. For the test trials, infants saw one of the novel familiarization objects alongside the other novel object from the original pair used in Experiment 3 (e.g., the pink felt blob and the green furry blob). If infants discriminate between two stationary novel objects, and if they remember the features of the familiar object, they should look longer in the test trials at the object to which they were not familiarized.

Method

Sixteen full-term 7-month-old infants (6 girls, 10 boys) participated in the study. Infants ranged in age from 6 months, 14 days to 8 months, 0 days ($M = 7$ months, 3 days). Two additional infants were excluded from the analysis due to failure to look sufficiently during familiarization. Twelve of the 16 infants also participated in a second experiment using the same method but different objects (Experiment 6; see later), with the order of experiments counterbalanced across infants.

The stimuli were the four novel objects used in Experiment 3, presented in the same test display and positioned in exactly the same way as on the previous test trials. As in Experiment 3, each infant saw one block of pink and green novel objects, and one block of blue and red novel objects. The order of presentation of the object pairs was counterbalanced, as was the object within each of the two pairs that was presented during the familiarization trials. That is, for each pair of objects (e.g., pink and green objects), half of the infants were shown two identical green objects during familiarization, and the other half of the infants were shown two identical pink objects during familiarization.

Each of the two experimental blocks was comprised of three familiarization trials followed by two test trials. On familiarization trials, infants saw two identical novel objects (e.g., two pink felt blobs). The objects remained visible until infants accumulated 10 sec of looking toward the display, and then the screen was lowered, removing them from view. On each test trial, infants saw one of the familiar-

ization objects and another novel object (e.g., the old pink felt blob and the new furry green blob). There were two 10-sec test trials, with the lateral position of the two objects reversed between trials.

During familiarization trials, one online coder measured infants' looking on a TV monitor in a room adjacent to the testing room. The online coder pressed a button box connected to a computer to indicate when an infant was looking at the display. When an infant accumulated 10 sec of looking on a trial the computer beeped to signal the end of the trial. The test trials were coded offline by two blind coders in a manner identical to the procedure described for Experiment 1. The average interrater reliability was 90%.

Results

Infants required, on average, a trial duration of 14.10 sec to accumulate 10 sec of looking at the experimental display for each familiarization trial. Figure 3 (novel objects) presents the mean looking time toward each object over the two test trials, collapsed across blocks. A repeated measures ANOVA with object (familiar, new) and block (1, 2) as within-subjects factors revealed a significant effect of nonsense object, $F(1, 15) = 6.80$, $p < .02$, $d = .82$. Infants looked longer at the new object ($M_{novel} = 10.12$ sec, $SD = 7.63$; $M_{familiar} = 5.17$ sec, $SD = 3.76$). Fourteen out of 16 infants looked longer at the new object. There was no significant main effect of block or interaction between object and block.
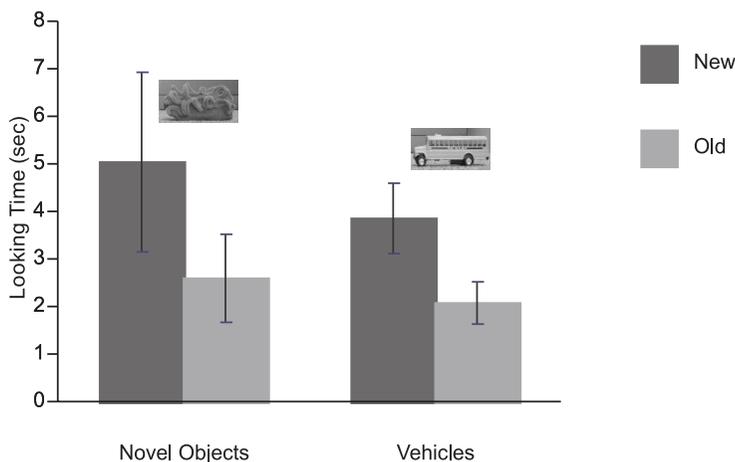
FIGURE 3   Test-trial looking times toward the object presented in the familiarization trials (old) versus the object first presented in the test trials (new) in Experiment 4 (novel objects) and Experiment 6 (vehicles), the two discrimination studies.

Discussion

Infants looked longer during test trials at the object that they had not previously been exposed to during familiarization. This finding demonstrates that infants can discriminate and remember the featural properties of each object, and it constrains our interpretation of the first three experiments. Whereas infants discriminate and remember the perceptual features of unfamiliar novel objects, they fail to learn the property of self-propelled motion for those objects. In contrast, infants successfully learn about self-propelled motion when they are tested with familiar animals undergoing familiar biological motion.

What is the source of this difference? Infants may fail to learn about the property of self-propelled motion for the novel objects solely because the objects are unfamiliar. For example, encoding the novel object features might demand greater attention than encoding the features of the familiar objects. Alternatively, infants may fail to learn about the property of self-propelled motion for any object that does not typically engage in self-propelled motion. As a third possibility, infants may fail to learn about the self-propelled motion of any object that is not an animal or that does not undergo biological motion. Experiment 5 was undertaken to distinguish the third possibility from the first two possibilities by presenting infants with a category of object that is familiar to them and that typically moves on its own but that is not animate. We tested infants' learning about a different category of familiar, self-propelled object: vehicles.

EXPERIMENT 5

Infants were presented with pairs of wind-up toy vehicles. Following the method of Experiment 1, one vehicle was released and moved on its own (SP), a second vehicle was held by a hand and moved passively (HG) during familiarization, and both vehicles were stationary during test. If infants only rapidly learn about self-propelled motion for objects with animal features or biological motion, they should look equally at the two vehicles during the test trials. In contrast, if infants are capable of learning about the self-propelled motion of any familiar object that characteristically moves in a self-propelled manner, they should look longer in the test trials at the vehicle that previously moved on its own.

Method

Sixteen full-term 7-month-old infants (8 girls, 8 boys) participated in the study. Infants ranged in age from 7 months, 0 days to 8 months, 0 days ($M = 7$ months, 14 days). Six additional infants were excluded from the analysis due to fussiness, parental interference, or error in the experimental procedure.

Four differently colored, uniquely textured, wind-up toy vehicles were used for Experiment 5: a blue Jeep, a yellow school bus, a dark green sport utility vehicle (SUV), and a black and red dump truck (panel D of Figure 1). Vehicles were made of metal, plastic, or both and were approximately 2×4 in. in size. The vehicles were yoked into two pairs based on appearance, such that the two vehicles in a pair differed in texture, shape, and color to the greatest degree possible (blue Jeep–yellow bus, and green SUV–black and red truck). The vehicles rolled across the stage in a smooth, fast movement. One of the vehicles entered from the side of the stage corresponding to the infants' right and moved to the left, and the other vehicle entered from the left side and moved to the right. Direction (right vs. left) and type of movement (SP vs. HG) were counterbalanced across the two blocks for each infant. Every infant saw both pairs of objects, one pair in each of the two blocks.

The procedure was identical to Experiment 1, with the exception that the vehicles moved more rapidly than the animals; to equate the distance traveled by the vehicles and animals, the vehicles moved for 6 sec rather than 8 sec (and were stationary for 6 sec rather than 4 sec) on each familiarization trial. Interobserver reliability averaged 94%.

Results

Familiarization Trials

Each infant's looking time during the familiarization period was analyzed by a repeated measures ANOVA with movement type (SP, HG) and block (1, 2) as within-subjects factors. This analysis indicated no significant effects, including no effect of movement type, $F(1, 15) < 1$. Infants looked equally long at SP and HG trials ($M_{SP} = 11.83$ sec, $SD = 1.16$; $M_{HG} = 11.81$ sec, $SD = 1.18$). Therefore, infants received equal amounts of exposure to SP and HG vehicles during familiarization, and they showed no preference for either vehicle or movement type.

Test Trials

Panel B of Figure 2 (vehicles) presents the total looking time to each of the objects over the two test trials, collapsed across blocks. A repeated measures ANOVA with movement type (SP, HG) and block as within-subjects factors indicated no significant main effect of movement, $F(1, 15) < 1$. Infants looked equally long at the SP and HG vehicles ($M_{SP} = 14.53$ sec, $SD = 4.45$; $M_{HG} = 14.40$ sec, $SD = 6.15$). There was a marginally significant main effect of block, $F(1, 15) = 3.53$, $p < .08$, $d = .57$. Infants looked longer overall at the two vehicles in the first block ($M_{block1} = 31.27$ sec, $SD = 9.07$) compared to the second block ($M_{block2} = 26.58$ sec, $SD = 7.39$). Eleven out of 16 infants looked longer at the SP vehicle during test trials.

A second analysis compared infants' learning about the movement behavior of an object when the stimuli were animals (Experiment 1) versus vehicles (Experiment 5). Data from Experiment 1 were used in this comparison because test trial duration (30 sec) was equal across the two studies. A repeated measures ANOVA with movement (SP, HG) as a within-subjects variable and stimuli type (animals, vehicles) as a between-subject variable revealed marginally significant effects of movement, $F(1, 30) = 3.76, p = .06, d = .7$, and a Movement × Stimuli Type interaction, $F(1, 30) = 3.34, p = .08, d = .66$.

Discussion

Infants in Experiment 5 showed no clear ability to learn about self-propelled objects when the objects were familiar vehicles. In addition, infants' tendency to look longer at a stationary object that previously moved on its own was marginally lower when the object was a vehicle (Experiment 5) than when it was an animal (Experiment 1). Because infants' learning about self-propelled animals was robust over variations in both the animals' sounds (Experiment 1A) and length of delay before test trials occurred (Experiment 2), the weaker evidence for learning in Experiment 5 suggests that infants learn more readily about self-propelled, familiar objects in the domain of animals.

As with infants' failure to learn about the novel objects in Experiment 3, there are two possible interpretations of the weak findings with vehicles. First, infants may best learn about self-propelled motion for animate objects. Second, infants may fail to discriminate between or remember the two vehicles from familiarization to test, despite the fact that the vehicles differed in both form and color. Experiment 6 was conducted to distinguish between these two possibilities.

EXPERIMENT 6

Experiment 6 used the method of Experiment 4 to test infants' discrimination between the vehicles used in Experiment 5.

Method

The method was identical to that of Experimenter 4, except as follows. The 16 participants included 6 female and 10 male full-term 7-month-old infants ranging in age from 6 months, 16 days to 8 months, 3 days ($M = 7$ months, 0 days). Two additional infants were excluded from the analysis due to lack of interest in the experimental stimuli resulting in failure to look sufficiently during familiarization. Twelve of the 16 infants who participated in Experiment 6 also participated in Experiment 4. Order of presentation of the nonsense objects and vehicles was coun-

terbalanced across these infants. The apparatus, events, design, procedure, and analyses were identical to Experiment 4 with the exception that the stimuli were the vehicle pairs used in Experiment 5. The average interrater reliability was 91%.

Results

Infants required, on average, a trial duration of 15.67 sec to accumulate 10 sec of looking at the experimental display for each familiarization trial. Figure 3 (vehicles) presents the mean looking time toward each vehicle over the two test trials, collapsed across blocks. A repeated measures ANOVA with vehicle (novel, familiar) and block (1, 2) as within-subjects factors revealed a significant effect of vehicle, $F(1, 15) = 13.95$, $p < .002$, $d = 1.45$. Infants looked longer overall at the new vehicle ($M_{novel} = 7.73$ sec, $SD = 3.02$; $M_{familiar} = 4.14$ sec, $SD = 1.75$). There was no main effect of block, but there was a significant Vehicle × Block interaction, $F(1, 15) = 6.51$, $p < .02$, $d = 1.32$. Infants looked significantly longer at the new vehicle only in Block 2, $t(15) = 4.40$, $p < .001$ ($M_{novel} = 4.37$ sec, $SD = 1.97$; $M_{familiar} = 1.52$ sec, $SD = 1.19$). In contrast, infants did not look significantly longer at the new vehicle in Block 1, although the pattern was in this direction ($M_{novel} = 3.34$ sec, $SD = 1.77$; $M_{familiar} = 2.63$ sec, $SD = 1.23$). Thirteen of 16 infants looked longer overall at the new vehicle.

A second analysis examined whether there was an interaction between the two discrimination experiments (4 and 6). A repeated measures ANOVA was conducted with object type (novel object, vehicle), familiarity (old, new), and block (1, 2) as within-subjects variables. As expected, there was a significant main effect of familiarity, $F(1, 11) = 12.48$, $p < .005$, $d = 2.12$, but no main effect of object type or block. The only other effect was a marginally significant Familiarity × Block interaction, $F(1, 11) = 4.59$, $p < .06$, $d = 1.29$.

Discussion

Infants looked longer during test trials at the vehicle that they had not previously observed during familiarization. This finding demonstrates that infants can discriminate and remember the featural properties of vehicles, and it constrains our interpretation of the first five experiments. Whereas infants discriminate and remember the perceptual features of vehicles and novel objects, they reliably learn the property of self-propelled motion only for animate objects.

GENERAL DISCUSSION

This set of studies investigated 7-month-old infants' capacity to learn a property of an object after minimal experience observing the object. In three studies, infants

mapped the motion behavior of a wind-up toy animal to that specific object after only three brief exposures. These findings provide evidence that humans have the ability to learn rapidly about self-propelled motion, at least for the category of animate objects, by the middle of the first year of life. Infants' learning about animate objects can occur in a single session and endure over a short delay period. These results support the notion that infants are actively engaged in the acquisition of object knowledge that includes information about how an object moves.

Interestingly, infants in Experiments 3 and 5 failed to demonstrate clear and consistent learning about the movement behavior of a novel object and a familiar vehicle, respectively, after similar experience with these objects. Importantly, Experiments 4 and 6 provided evidence that infants' failure to learn the movement behavior of a novel object or vehicle did not result from infants' inability to discriminate between the two objects. Nevertheless, the absence of a significant difference between infants' learning about vehicles (Experiment 5) compared to animals (Experiment 1), leaves open the possibility that infants have some capacity for learning about a broader range of self-propelled objects.

Infants' failure to learn the movement behavior of the inanimate objects in Experiments 3 and 5 speaks to questions concerning the kind of learning infants demonstrated in Experiments 1, 1A, and 2. First, these findings indicate that infants' learning about toy animals was not a secondary consequence of the low-level display differences in the way hands interacted with the objects, because the hands behaved exactly the same way in Experiments 1, 1A, and 2 (with animals) and in Experiments 3 and 5 (with novel objects and vehicles). Second, infants did not simply learn an association between hand position (on or off the object) and object motion (moving or stationary) because the same associative relations were present in all of the experiments. Despite identical behavior with the different kinds of objects, and identical associations between hand contact and object motion, infants showed reliable preferences for the self-propelled object only in the experiments with animals. Thus, infants' learning depended on the objects and their motions, not the behavior of the hands, ruling out a simple associative learning account.

One pertinent question is whether infants' previous knowledge of the stimulus objects is brought to bear in these studies. Infants in these studies showed rapid learning about the movement behavior of wind-up toy animals, raising the question of whether they interpreted the toy model animals and vehicles used in these studies to be representations of real animals and vehicles. Differences in learning about the movement behavior of the animals versus the novel objects suggests that real-world knowledge of the objects could be essential for learning to occur. However, the absence of a strong learning effect for the vehicles suggests that infants might not have connected these objects to real-world categories.

One possibility is that even though infants were able to learn specific properties of objects within the constraints of our tasks, they do not relate these objects to real animals and vehicles by 7 months of age. Findings from previous research that

used toy animals as stimuli suggest that infants do treat toy replicas as representations of real animals. For instance, infants distinguish toy animals from toy artifacts when given the chance to manipulate the objects, even with very artificial toy replicas (Pauen, 2002). However, other studies raise doubts about whether young infants view the toys typically used in categorization studies as representations of real entities (e.g., Younger & Johnson, 2004). Experiments with video displays of real animals might speak to this question (Ganea & DeLoache, 2005).

What factors allow infants to rapidly learn about self-propelled objects? Taken together, the only difference between the studies in which infants showed robust learning (Experiments 1, 1A, and 2) and those in which infants showed little or no learning (Experiments 3 and 5) concerned the presence or absence of familiar animate features and biological, jointed motions. These features and motions may have influenced infants' differential learning for any of three reasons. First, infants may learn about self-propelled objects only for objects in the domain of animals. That is, the property that infants learn about may be animacy, and animacy may be attributed only to objects with a face, body parts, or both. The ability to recognize whether a given object is animate or inanimate, and additionally, to reason appropriately about the behavior of each type of object, appears to be in place in the first year of life (Mandler & McDonough, 1998; Spelke et al., 1995).

Second, infants may learn about self-propelled objects only when they undergo a pattern of biological motion—that is, when they exhibit the smooth, natural movements typical of living things. Infants are sensitive to biological motion from an early age (Bertenthal, Proffitt, Spetner, & Thomas, 1985), even in displays lacking any animate features. On either of these two views, infants may possess core knowledge in the domain of animate objects that enables them to learn and reason about self-propulsion only for animate objects that behave or look like animals (Spelke, 1994).

Third, infants may learn about self-propelled objects only when they observe an object engage in a salient pattern of jointed motion, such as the bending of an animal's legs or turning of an animal's head, the opening and closing motions of a truck's crane, or the fanning motion of a windmill. It is possible that the articulated motion of the animals' legs in Experiments 1 and 2 cued infants to attend to the differing movement type of the two objects, and in turn enabled them to learn this feature of the objects. On this view, because neither the novel objects nor the vehicles had salient, articulating parts, infants failed to attend sufficiently to this feature of the objects, resulting in no learning or weaker learning about the motion behavior of the objects.

Current studies are attempting to tease this issue apart by examining infants' capacity for rapidly learning about self-propelled motion using interesting vehicles that exhibit salient, moving parts and animals that move about in an uninteresting, nonjointed fashion. If infants in these studies learn about the self-propelled motion of the vehicles (but not the animals), it would suggest that they more readily learn

about self-propulsion for jointed movement, supporting the notion that infants rely on functional parts for this kind of learning (Rakison, 2003). Future research should enable us to distinguish these possibilities and to examine further the limits of infants' learning about unfamiliar or inanimate self-propelled objects.

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