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The Cat is out of the Bag: The Joint Influence of Previous Experience and Looking Behavior on Infant Categorization

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We examined the effect of 4-month-old infants' previous experience with dogs, cats, or both and their online looking behavior on their learning of the adult-defined category of *cat* in a visual familiarization task. Four-month-old infants' (N = 123) learning in the laboratory was jointly determined by whether or not they had experience with pets at home and how much they shifted their gaze back and forth between the stimuli during familiarization. Specifically, only infants with pets at home who also exhibited high levels of switching during familiarization remembered the individual cat exemplars or formed a summary representation of those cats. These results are consistent with recent theorizing about the processes of how infants' categorical representations are formed, and provide new understanding into how infants' categorization unfolds over time.

Infants are excellent categorizers. They respond to a variety of categories, such as human faces, dogs, cats, horses, and dot patterns (Bomba & Siqueland, 1983; Oakes & Ribar, 2005; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002; Younger & Fearing, 2000). They learn categories based on correlations among attributes (Rakison, 2004; Younger, 1985) and form prototypes (Bomba & Siqueland, 1983). Although researchers have studied categorization for over 20 years (Rakison & Oakes, 2003), we know little about the factors that determine how infants learn cat-

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egories in laboratory tasks. For example, investigators are only just beginning to uncover the effects of knowledge gained outside the laboratory on infants' responding in the laboratory (Quinn et al., 2002), and how opportunities to compare items online influence infants' responding in those tasks (Oakes & Ribar, 2005; Younger & Furrer, 2003). Understanding the effects of such factors on infants' categorization in the laboratory provides insight into how categories are learned over time, and uncovers processes that likely influence the kinds of representations infants form and revise as they encounter items in the "real world."

In this investigation we examined the influence of two factors—existing knowledge and online looking behavior—on infants' learning about a collection of items in a laboratory task. Understanding the influences of these two factors—both the independent and joint influences—is important for several reasons. There recently has been intense interest in the role of infants' existing knowledge on their performance in laboratory tasks, motivated in part by Mandler's (2004) claim that infants' existing knowledge influences their performance in object handling tasks (because they reflect conceptual categorization processes), but not in looking tasks (because they reflect online perceptual categorization).

In fact, the evidence suggests that previous knowledge influences infants' performance in both types of tasks. Using an object examining task, Pauen (2002) observed that 10- to 11-month-old infants responded to the distinction between furniture and animals both when the between-category exemplars shared several perceptual properties and when they shared few perceptual properties. Pauen concluded that online perceptual processes alone cannot account for these results, and therefore infants' responding reflects previous knowledge. Using a visual familiarization task, Quinn et al. (2002) found that 3- to 4-month-old infants with female primary caregivers formed an exclusive category of relatively unfamiliar male faces (i.e., a category that excluded female faces), but remembered individual items from the more familiar category of female faces (for the effect of caregiver's race see Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2007; Kelly et al., 2005). Indeed, Quinn (2002) proposed that experience with exemplars from a particular category changes infants' categorization from forming a summary representation or prototype of exemplars to remembering each individual exemplar as well as maintaining a summary representation. Importantly, infants' performance in both looking and object handling tasks appear to be influenced by their previous experiences, supporting the general conclusion that similar processes are involved in both tasks (Oakes & Madole, 2003; Younger & Fearing, 1998; Younger & Furrer, 2003).

However, our knowledge of this influence on infants' responding is incomplete. Both Pauen (2002) and Quinn et al. (2002) compared infants with the same previous experience (e.g., a female caregiver) who were familiarized with different stimuli (e.g., perceptually similar vs. perceptually variable pieces of furniture, familiar female faces vs. relatively novel male faces). Consequently, such results could reflect either the effect of previous experience or physical differences between the two stimulus sets. Although Quinn et al. ruled out the effect of a number of potential physical differences, it is important to extend this work by comparing how infants with different previous experience respond to the same stimuli. (Quinn et al. did report that infants reared by male caregivers showed a spontaneous preference for male faces, but because few infants are reared by male caregivers the model was not fully tested.)

Further, it is unclear if such effects would be observed for experience with arguably less familiar categories such as cat or dog. If the effect of experience is not specific to a particular categorical contrast, set of stimuli, or the kind of extensive experience infants have with human faces, experience outside the laboratory with less familiar categories also should influence infants' responding in the laboratory. Quinn (2004) did report no difference in responding to a subordinate-level category (e.g., Siamese cat) by a very small sample of 6- to 7-month-old infants with pets at home ($n = 7$) and a sample who did not have pets at home ($n = 41$). Nevertheless, exposure to pets may influence infants' performance in a basic-level categorization task or at a different point in development. Moreover, the effect of such experience may be revealed if it is tested with more statistical power. This was one goal of this investigation.

Another factor that likely influences infants' categorization is their online looking behavior. It is well-established that between 3 and 6 months of age infants who exhibit longer looks at stimuli engage in less sophisticated learning of those stimuli, particularly with respect to their response to details (Bronson, 1991; Colombo, Mitchell, Coldren, & Freeseman, 1991; Jankowski & Rose, 1997; Jankowski, Rose, & Feldman, 2001). Thus, infants who exhibit more, shorter glances at stimuli in a categorization task may process more details of the stimuli. Moreover, this individual difference may be relevant to how categorization is assessed in young infants. Often, stimuli are presented in pairs, providing the opportunity to compare those items without relying on memory. Items presented side by side can be compared by simply looking back and forth between them. Thus infants who look back and forth between the stimuli more have more opportunities to compare them. Short lookers may not only process more details, but they also may shift their gaze back and forth between the stimuli more than do longer lookers.

Indeed, presenting items in pairs does influence infants' categorization (Kovack-Lesh & Oakes, 2007; Oakes & Ribar, 2005; Reznick & Kagan, 1983; Younger & Furrer, 2003). For example, Oakes and Ribar (2005) found that 4-month-old infants responded to an exclusive category of cats that did not include dogs (and vice versa) when the stimuli were presented in pairs, but failed to respond to that exclusive category when the exact same stimuli were presented one at a time. Given the effects of long versus short looking just described, we reasoned that when presented with items in pairs, infants who shift their gaze back and forth between the two pictures more frequently may be engaging in more online comparison of items, and therefore may show more sophisticated encoding and learning of the stimuli.

Such glancing at different parts of the stimulus display does influence infants' learning of some stimuli. Johnson, Slemmer, and Amso (2004) found that infants' scanning patterns when familiarized with the classic "rod-and-box" event pioneered by Kellman and Spelke (1983) predicted whether or not they perceived the rod pieces as parts of a unified rod moving behind an occluder. Specifically, infants who ultimately perceived the pieces as unified scanned back and forth between the rod pieces more during familiarization than did infants who did not perceive those pieces as unified. Rose and colleagues (Jankowski et al., 2001; Rose, Feldman, & Jankowski, 2003) found that infants who had briefer and more numerous shifts of their glance around a stimulus showed stronger novelty preferences in a standard visual recognition memory task than did infants who engaged in fewer, longer looks (and fewer shifts of their gaze). Rose et al. (2003) suggested that rates of shifting may reflect the propensity for active comparison. Indeed, Jankowski et al. (2001) found that long lookers (as established during a pretest) who were then induced to shift their gaze more to different parts of the stimuli during familiarization (i.e., a red light moved from quadrant to quadrant of the stimuli) performed like short lookers on a test of visual recognition memory. In general, infants who engage in more numerous briefer glances, perhaps in particular those glances that sample more different parts of the visual display, appear to learn more about stimuli than infants who engage in fewer longer glances.

Previous work, therefore, demonstrates that both infants' experience and their online looking behavior independently influence what they learn during a visual familiarization task, pointing to the important roles of both real-time and developmental-time processes. It is becoming increasingly clear that what infants learn is jointly determined by multiple factors (Thelen & Smith, 1994), and an important goal for research is to understand the joint contribution of these factors to infants' learning. Therefore, here we examined the combined roles of infants' experience with pets and individual differences in online looking behavior on their learning of a collection of items from the adult-defined exclusive category of cats. In addition to identifying individual differences in looking behavior, we examined the effect of infants' experience with pets on their categorization of cats by comparing the responding of infants who are exposed to a pet at home to that of infants who are not exposed to a pet at home (approximately half of the infants who come to our laboratory have pet experience). Therefore, we compared the responding of four groups of infants—high-switching infants with pets, low-switching infants with pets, high-switching infants without pets, and low-switching infants without pets. It was not clear a priori whether pet experience or online looking behavior would have a stronger influence on infants' responding, or whether the interaction of the two factors would lead to differences in infants' categorization.

We assessed 4-month-old infants' learning of a collection of cats in a visual familiarization task. Following familiarization with 12 different, highly variable cats, we assessed infants' response to the categorical distinction between dogs and cats or their memory for the individual items. It is possible that looking behavior and pet experience may influence both infants' formation of a summary of the category and their learning of the individual items they are shown. Indeed, according to Quinn's (2002) model, only at the highest level of sophistication do categories include information both about exemplars and about the commonalities that characterize a category (i.e., a prototype). Thus, we will gain the deepest understanding into the sophistication of infants' representation if, following familiarization to a collection of items, we evaluate both infants' memory for the individual items and their summary representation.

METHODS

Participants

The final sample consisted of 123 full-term, healthy 4-month-old infants (M = 122.04 days, SD = 8.31 days; 61 girls, 62 boys) with no history of vision problems. Ninety-eight infants were tested at the University of Iowa; 25 infants were tested at the University of California, Davis (UC Davis). The two groups of infants did not differ in age, $p = .65$, or maternal education (76% of the mothers at the University of Iowa and 80% of the mothers at UC Davis had a bachelor's degree). Seventy-five infants had indoor pets at home or were exposed to pets for more than 20 hr per week at day care (57 at the University of Iowa and 18 at UC Davis); 37 infants had cats, 24 had dogs, and 14 had both. The remaining 48 infants did not have indoor pets at home (41 at the University of Iowa and 7 at UC Davis). In Iowa, we obtained infants' names from county birth records and contacted parents by letter and a follow-up phone call. In California, family names were purchased from a professional list broker, and parents were sent a letter with a postage-paid card they could return if they wished to participate. All infants received a small toy or t-shirt for their participation and parents were reimbursed for their parking expenses. The data from 40 additional infants (33 at the University of Iowa and 7 at UC Davis) were excluded from the final analyses due to failure to complete all trials ($n = 32$), side bias (i.e., looking at least 95% to one side during familiarization; $n = 1$), experimenter error ($n = 4$), or parental or sibling interference ($n = 3$). On the basis of parental report of infants' exposure to cats and dogs, infants were assigned to a pet group (those exposed to indoor pets at home or at day care for at least 20 hr a week) or a no-pet group.

Stimuli

Stimuli were digitized photographs of 18 cats and 18 dogs. The collections of dogs and cats were highly variable (see Figure 1). There were 18 different breeds of

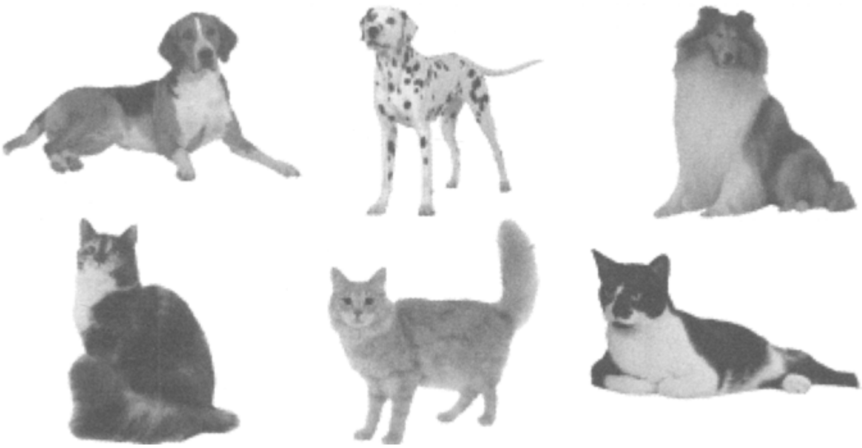

FIGURE 1 Examples of stimuli used in the experiments.

dogs and 16 different breeds of cats (the two cats of the same breed were very different in coloring and markings). The coloring and markings within the set is representative of the range of coloring and marking within aa range of domesticated cats and dogs. In addition, animals were in one of three different stances: seven dogs and eight cats were standing, five dogs and four cats were sitting, and six dogs and six cats were lying down. Finally, 16 dogs and 16 cats had their full faces visible (e.g., two eyes, both ears, mouth, and nose), and two dogs and two cats had only partial faces visible (e.g., one side of the face in profile). Images were altered using Adobe Photoshop to be approximately the same size, brightness, and contrast, and were approximately 19.0 cm × 14.5 cm (subtending approximately 27° × 21° visual angle at 40 cm viewing distance).

To assess infants' a priori preferences for the stimuli, a separate group of 56 4-month-old infants (M = 121.29 days, SD = 8.23; 24 girls and 32 boys; 18 had cats, 13 had dogs, 11 had both, and 14 had none) were presented with 12 individual stimuli (randomly chosen from the set, with the constraints that across infants (a) each item occurred equally frequently, (b) items were paired with all the other items, and (c) each pair occurred equally frequently) on six 10-sec trials; two trials with a cat paired with a dog, two trials with a dog paired with a vehicle, and two trials with a cat paired with a vehicle (left–right position of the items counterbalanced across trials). Trial order was pseudo-randomly determined such that the first trial was always a cat–dog trial and the other cat–dog trial occurred in one of the other five trial positions (the animal–vehicle trials were randomly ordered across the remaining four trials). Infants' preferences for dogs (on the first type of trial) and their preference for trucks (in the other two types of trials) are presented in Table 1. The means are provided for the sample as a whole, as well as for the subset of infants with cats, those with dogs, those with both cats and dogs, and those with no pets. The mean prefer-

TABLE 1
Mean Preferences for Dogs Over Cats and for Vehicles Over Animals as a Function of Pet Experience

		Preference for Dog Over Cats		*Preference for Vehicle Over Animal*	
	N	*M*	*SD*	*M*	*SD*
Pets at home					
Cats	18	.47	.14	.55	.12
Dogs	13	.43	.18	.53	.13
Both dogs and cats	11	.51	.14	.59	.08
No pets	14	.50	.17	.56	.14
Entire sample	56	.48	.16	.55	.11

ence for dogs in the dog–cat trials (M = .48, SD = .16) did not differ from chance (.50), $t(55) = .99$, *ns,* two-tailed. We confirmed that none of the preferences for the dog in the cat–dog trials for any of the individual groups was significantly different from chance, all $ps > .20$, two-tailed, nor did they differ from each other. The mean preference for vehicles in the animal–vehicle trials ($M = .55$, $SD = .12$) did differ significantly from chance, $t(55) = 3.50$, $p < .001$, two-tailed, $d = .59$; therefore, because longer looking at test to a vehicle after being familiarized with cats would be ambiguous, vehicles were not used in the main experiment.

Apparatus

The testing apparatus was nearly identical in the two institutions—the monitors were the same make and brand, and the computers were Macintosh G4 or G5 computers with comparable video cards. At each institution, infants were tested in a dimly lit room. Black curtains divided the room and obstructed the infants' view of the computer equipment and the observer. Openings in the curtain revealed two 17–in. (43.2 cm) ViewSonic computer monitors; center-to-center distance of the monitors was 52 cm. Another opening in between the computer monitors revealed a small, black box that blinked and produced a beeping sound at a rate of 3 Hz to orient infant attention between the monitors during the intertrial interval. A final opening revealed a small, low-light TV camera lens positioned below the blinking light. Stimuli were presented via a Macintosh computer using software developed for the Macintosh (Cohen, Atkinson, & Chaput, 2000).

Procedure

Infants were seated on their parents' laps 40 cm from the monitors. Parents wore opaque glasses to avoid bias. A trained observer (unaware of the infant's experimental condition, the particular stimuli being shown, and whether or not the infant had pets at home) sat on the other side of the curtain and viewed the infant on a small TV monitor (sessions were recorded for establishing reliability). Each trial began with the blinking, beeping light. When the infant was judged to be looking at the blinking light, the observer initiated trials by pressing a key on the computer keyboard. This key press simultaneously ended the attention-getting stimulus and presented the two stimuli (one on each monitor) for each trial. During the trial, the infant was free to look at either stimulus as long as he or she wished (if no looking was observed in the first 5 sec the trial was stopped and repeated). The observer timed look durations by pressing one computer key when the infant looked to the left and a different key when the infant looked to the right. The computer recorded the total duration of these key presses for each trial as the total duration of right and left looking. Reliabilities calculated between the online coding and a second trained observer (coding looking time from the recorded session) for 25% of the sample reported here were very good: Mean interobserver correlation for the duration of looking on each trial for all studies was high (average $r = .97$), and mean absolute difference between observers for the duration of looking was low for all studies (average $M = .49$ sec). Note that we had the same observers at both institutions; reliabilities reflect observers from both institutions. Only the original online data are reported.

Infants received six 15-sec familiarization trials. On each trial infants were presented with two different cats, for a total of 12 cats (randomly chosen from the total set of 18). Thus, each individual cat was seen only once, on a single 15-sec trial, in the context of a different cat. Immediately following familiarization, infants were presented with two 10-sec test trials. The same pair of stimuli was presented on each test trial, left–right position counterbalanced across trials. The test items for each infant were pseudo-randomly chosen, with the constraint that each individual item occurred approximately equally as a novel and familiar test, and that each time an item appeared it was paired with a different novel item. Infants were randomly assigned to either a category condition (30 girls, 31 boys) or an exemplar condition (31 girls, 31 boys). Infants in the category condition were presented with a novel dog paired with a novel cat. If infants learned the exclusive category of cat during familiarization, they should prefer the novel dog to the novel cat. Infants in the exemplar condition were presented with a randomly chosen previously seen cat paired with a novel cat. If infants learned the individual cats presented during familiarization, they should look longer at the novel cat than at the familiar one.

RESULTS

Preliminary Analyses

Initial analyses revealed that responding did not vary systematically as a function of infants' gender, and thus gender was not included in any of the reported analyses. In addition, those infants who had pets at home did not respond differently as a function of whether or not they had a cat at home, all *ps* > .14; a somewhat surprising effect given that we familiarized infants only with cats. However, because no differences existed, to increase our power we collapsed across particular pet experience and report a single pet group.

To establish individual differences in looking behavior, for each infant we determined the number of switches during each familiarization trial from the online record of his or her looking. The computer program we used for collecting online looking generated a record of each individual look during each trial (the duration and whether it was to the right or left monitor), allowing us to determine how often infants switched their focus from the left to the right stimulus, and vice versa. A switch was defined as any instance when the infant looked first to one screen and then to the other (even if the infant looked away in between looks). Two looks in a row to the same screen (e.g., look to the right, look at the ceiling, look to the right) did not count as a switch. Reliability for the number of switches was determined from the online coding and the offline coding described earlier. Again, reliability was good; the mean interobserver correlation for the number of switches on each trial was high (average $r = .89$), and mean absolute difference between the number of switches between observers was low (average $M = .43$).

We elected to count only looks from one monitor to the other as a switch—eliminating any looks in which the infant looked at one monitor, away, and then back at that same monitor. This is the standard in the literature (Jankowski & Rose, 1997; Jankowski et al., 2001; Rose et al., 2003; Ruff, 1975). Moreover, because our interest was in infants' comparison of different stimuli, this measure is appropriate. Importantly, this measure represents gross switches of attention, rather than more subtle switches from one part of the animal to another that can only be measured accurately using an eye tracker.

We could have examined other individual differences in looking behavior. The total number of glances at the monitor, for example, might have been the most informative measure. In fact, switching was highly correlated with the number of looks (i.e., including successive looks to the same monitor), $r(121) = .94, p < .001$, suggesting that infants who looked back and forth between the two monitors more also engaged in more looks away from the monitors to the camera, parent, door, and so on. Moreover, we conducted the analyses we report later using both the number of switches (as reported) and the total number of looks and obtained the same results. Thus, at this point we cannot differentiate between these two possibilities (i.e., actually switching between the two monitors and the number of glances) because these two measures overlap considerably. Future work, in which infants' switching behavior can be experimentally manipulated, will need to disambiguate these possibilities.

We also could have examined the average duration of looking on each trial. The average number of switches infants made during each familiarization trial was negatively correlated with the duration of individual looks, $r(121) = -.36, p < .001$, suggesting that high switchers also exhibited shorter individual looks. Thus, our high-switching infants may be high comparers or short lookers. Despite the overlap with these different measures, we report here the switching measure described earlier to make our results as comparable as possible to other results reported in the literature (Jankowski & Rose, 1997; Jankowski et al., 2001; Rose et al., 2003; Ruff, 1975). We revisit these issues in the General Discussion.

To examine whether switching varied as a function of experience with pets or across familiarization with cats in our experiment, the number of switches on each familiarization trial was entered into a mixed-design analysis of variance (ANOVA) with trial as the within-subjects factor and pet group as the between-subject factor. This analysis revealed only a main effect of trial $F(5, 605) = 6.81, p < .0001$, partial $\eta^2 = .05$, due to infants' switching less as the session progressed. Tukey–Kramer post-hoc tests revealed significant differences between Trial 1 ($M = 3.92, SD = 2.80$) and Trials 3 ($M = 3.13, SD = 2.51$), 4 ($M = 2.96, SD = 2.83$), 5 ($M = 2.76, SD = 2.27$) and 6 ($M = 2.37, SD = 2.05$), $p < .05$. Trials 2 ($M = 3.16, SD = 3.00$) and 6 ($M = 2.37, SD = 2.05$) also were significantly different, $p < .05$. Interestingly, there was no effect of pet group on the average number of switches across the six familiarization trials (pet group $M = 2.96, SD = 2.50$; no-pet group $M = 3.19, SD = 2.83$), $F(1, 121) = .54$, *ns*, suggesting that infants for whom the particular type of stimuli was more familiar (i.e., infants with pets at home) engaged in the same level of switching as did infants for whom this type of stimuli was less familiar.

We split the sample at the median to divide infants into two switching groups based on the number of switches made on average during familiarization trials: a high-switching group ($M = 4.28$ average switches per trial, $SD = 1.47, n = 62$) and a low-switching group ($M = 1.81$ average switches per trial, $SD = .68, n = 61$). The average number of switches made by the two groups was significantly different, $t(121) = 11.93, p < .0001$, two-tailed, $d = 2.16$, but they did not differ in age, $t(121) = -.68$, *ns*. However, approximately the same number of pet and no-pet infants were in each of the switch groups (38 high switchers had pets at home, 24 high switchers did not have pets, 37 low switchers had pets at home, and 24 low switchers did not have pets), $\eta^2 = .005$, *ns*. Thus, the main way the two groups differed was in their level of switching.

Familiarization

To examine changes in infants' looking during familiarization, a mixed-design ANOVA was conducted on infants' looking during the first and second block of three familiarization trials with pet experience (pet, no pet), condition (category, exemplar), and switching group (high, low) as between-subject factors. This analysis revealed a main effect of block, $F(1, 119) = 5.35, p < .05$, partial $\eta^2 = .04$, due to a decrease in looking from Block 1 ($M = 9.10$ sec, $SD = 2.49$) to Block 2 ($M = 8.50$ sec, $SD = 3.20$). Thus, as is typical in this procedure (Oakes & Ribar, 2005) infants showed a modest but significant decrease in looking over the course of familiarization. Interestingly, infants with pets at home did not differ in their looking or rate of decrease in looking from infants without pets at home.

Test Phase

Our primary concern was whether infants exhibited a novelty preference at test. We created a novelty preference score for each test trial by dividing the duration of looking to the novel item on that trial by the total amount of looking to the novel and familiar items combined. We then averaged the novelty preference scores for the first and second test trials. Note for infants in the category condition, the novel item is the new dog and the familiar item is the new cat. For infants in the exemplar condition, the novel item is the new cat and the familiar item is the cat seen during familiarization.

To test for the joint influences of looking behavior and previous experience on infants' learning, we conducted an ANOVA on infants' average novelty preference score at test with test condition (category, exemplar), pet group (pet, no pet), and switching group (high, low) as between-subject factors. The ANOVA yielded only a Switching Group × Pet Group interaction, $F(1, 115) = 4.87, p < .05$, partial $\eta^2 = .04$, suggesting that infants' previous experience with pets together with their looking behavior influenced infants' responding across the category and exemplar test conditions (see Figure 2). (It should be noted that 9 infants failed to compare both stimuli on both test trials—they only looked at one monitor on each of the test trials, resulting in an average preference score of 0, .5, or 1. We conducted our analyses excluding these infants and obtained the same pattern of results. Thus, we elected to report the more conservative analysis including all the infants.)

To further explore this interaction, we conducted a series of follow-up two-tailed t tests. We compared the novelty preference exhibited by infants in the pet/high switching group to the other groups: Indeed, these infants had a significantly greater novelty preference than did infants in the no-pet/high switching group, $t(60) = 2.85, p < .01, d = .35$, and infants in the pet/low switching group, $t(73) = 2.35, p < .05, d = .27$, and marginally greater novelty preference than did infants in the no-pet/low switching group, $t(60) = 1.76, p = .08, d = .22$. Infants in the two no-pet groups did not differ significantly from each other, and the two groups of low switching infants did not differ significantly from each other, $ps > .32$. It is not entirely clear why the two groups that one might predict should be the most different from one another (pet/high switching group and no-pet/low switching group) in fact are only marginally different. Inspection of Figure 2 shows that the vast majority of the high-switching infants with pets at home had novelty preference scores above .50, whereas infants in the no-pet/low switching group were approxi-

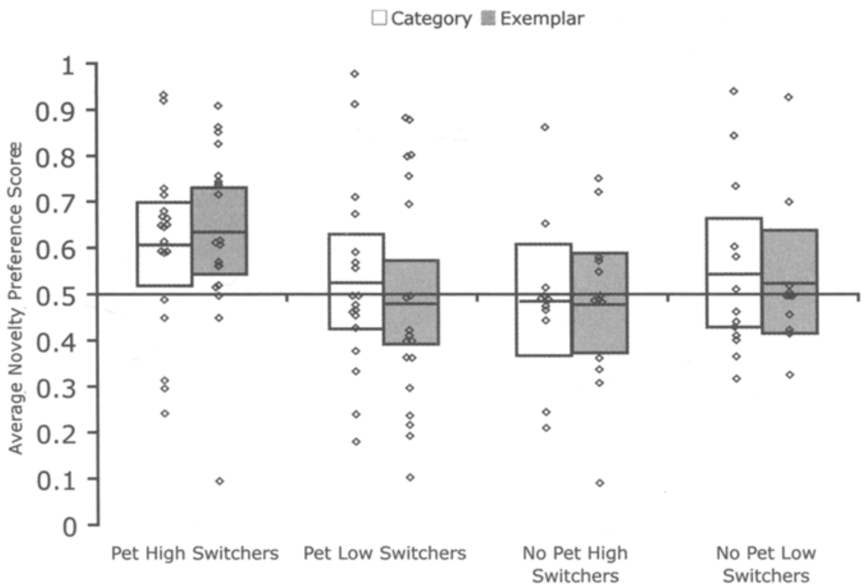

FIGURE 2 Preference scores for all four groups in Experiment 1. Individual preference scores for each infant are represented by a diamond. The upper and lower horizontal edge of the box represents 95% confidence intervals, and the horizontal line bisecting the box represents the mean preference score for the group.

mately split between infants who had preferences above and below .50 (see also Table 2). At this point, therefore, it is premature to draw firm conclusions either about the difference or lack of difference between these two groups. The general pattern considering all four groups suggests that infants' responding is jointly determined by these two factors. Additional research will need to be conducted to de-

TABLE 2
Number of Infants With Novelty Preference Scores Greater Than Versus Less Than or Equal to .50 (Chance) During Test for Each Group of Infants

	Pets		*No Pets*	
	High Switching	*Low Switching*	*High Switching*	*Low Switching*
Preference	30	13	8	10
No preference	8	24	16	14

Note. Novelty preference scores were calculated by dividing infants' looking to the novel item by their total looking during test.

termine whether the failure of this one comparison to reach significance is replicated.

Although our initial analyses revealed no significant effect of the type of pet infants have at home on their responding here, it is possible that infants' novelty preference for a new cat or dog was influenced by their exposures to dogs versus cats. Thus, we compared the novelty preference for high-switching infants who only had cats at home or day care to the novelty preference for high-switching infants who had dogs at home or daycare (a few who also had cats). The two groups did not differ, $t(36) = 1.25$, *ns*, confirming our initial impression that whether or not infants had a *cat* was less important than whether or not they had a *pet* at home.

To determine whether this effect was actually due to the amount of *switching*, and not some other individual difference correlated with switching behavior, we conducted a second ANOVA examining the effect of infants' average look duration on their learning. We split the sample at the median into two groups based on the average looking duration during the familiarization trials: a long looking group ($M = 9.94$ s per trial, $SD = 1.18$, $n = 62$) and a short looking group ($M = 5.86$ s per trial, $SD = 1.60$, $n = 61$). The average look durations for the two groups was significantly different, $t(121) = 16.12$, $p < .0001$, two-tailed, $d = 2.90$, as was the number of switches during familiarization, $t(121) = 2.15$, $p < .05$, $d = .39$ ($M = 20.23$, $SD = 10.49$, for infants with long looking on average and $M = 16.36$, $SD = 9.43$, for infants with short looking on average). However, the ANOVA conducted on infants' average novelty preference score using look duration group as a between-subject variable revealed no significant effects, all $ps > .13$, suggesting that long or short looking was not predictive of difference in novelty preferences.

We confirmed our main conclusion that infants with pets who were also in the high-switching group responded differently at test than did infants in the other groups with a log-linear analysis conducted on the contingency of pet group (pet, no pet), switching group (high, low) and preference (preference score > .50, preference score = .50). In our sample, 61 infants had a novelty preference score > .50, and 62 infants had a novelty preference score = .50. This analysis yielded a significant Preference × Pet Group interaction, $G^2(1) = 9.28$, $p < .01$, and a significant Preference × Pet Group × Switching Group interaction, $G^2(2) = 27.54$, $p < .0001$ (see Table 2; as for the analyses reported earlier, the corresponding analysis conducted excluding the infants who failed to compare at test yielded essentially the same results). The first effect indicates that infants with pets were more likely to respond to the novel item at test than were infants who engaged in less switching during familiarization. The second effect, however, suggests that this effect is moderated by level of switching. Specifically, infants who had previous experience with pets and also engaged in high levels of switching were the most likely to respond to the novel item at test.

Comparison of Infants' Responding to Chance

Finally, to establish whether any of these groups responded to the novel item more than would be expected by chance, we used two-tailed t tests to compare the preference scores for each of the four groups (pet/high switching, pet/low switching, no pet/high switching, and no pet/low switching) to chance (.50). The analyses just described reveal that infants who had pets at home and engaged in high levels of switching exhibited higher novelty preference scores than did infants in the other groups, but these analyses do not reveal whether or not any group responded to the novel item more than would be expected by chance (.50). Note that in some studies, infants' preference to a novel category item has been compared to an a priori preference. This comparison is not appropriate here due to differences in the procedures used in the preference and main tasks. Therefore, both category and exemplar groups were compared to chance responding.

The mean preference scores and corresponding t test comparing those scores to chance are presented in Table 3 for each group of infants. Only infants in the pet/high switching group responded to the novel item more than we would expect by chance. Moreover, high switchers with pets both learned the individual exemplars and responded to the category. None of the other groups responded at more than chance in either task. Therefore, only infants who were high

TABLE 3
Mean Preferences for New Item as a Function of Pet Group and Amount of Switching During Familiarization

	N	M	SD	t	D
Pet/high switchers					
Overall	38	.62	.19	3.98***	.89
Category test	19	.61	.19	2.48*	.82
Exemplar test	19	.64	.19	3.08**	1.04
Pet/low switchers					
Overall	37	.51	.23	.21	.06
Category test	18	.53	.21	.54	.20
Exemplar test	19	.49	.25	.17	−.06
No pet/high switchers					
Overall	24	.49	.17	.41	−.08
Category test	11	.49	.18	.20	−.08
Exemplar test	13	.48	.18	.36	−.16
No pet/low switchers					
Overall	24	.54	.18	1.0	.31
Category test	13	.54	.19	.83	.30
Exemplar test	11	.53	.17	.57	.25

*$p < .05$. **$p < .01$. ***$p < .001$. All two-tailed.

switchers and who had pets at home significantly preferred the novel item in both conditions.

Tests of Discrimination

We tested infants' discrimination of the within-category items using a strategy recently adopted by Mareschal and his colleagues (Mareschal, Powell, & Volein, 2003) which allows us to evaluate infants' discrimination of the items in the context of the categorization task. We measured a number of features (leg length, vertical extent, horizontal extent, head width, eye separation, ear width, ear length, and nose length) of the two stimuli presented on the first familiarization trial. We then created a difference score for each feature by subtracting the value for the left stimulus from the value for the right stimulus (e.g., if the black-and-white tabby was on the left and the Maine Coon was on the right, the difference score for vertical extent would be 23.3 [Maine Coon vertical extent] – 21.6 [black-and-white tabby vertical extent] = 1.7). Although not all possible combinations of items appeared as the first trial, most items were paired with two or three other items across the sample of infants; thus, by examining discrimination across the sample as a whole we gain insight into whether infants generally discriminated among the items during the familiarization phase of this experiment.

To establish whether infants could distinguish between the individual items presented on Trial 1, we correlated the difference score for each feature with the infants' preference for the stimulus presented on the right (i.e., the infants' right preference, calculated as the looking to the right divided by the total amount of looking on Trial 1). The logic is that if infants discriminate between the items, their preference for the right stimulus will be systematically related to the difference in one or more of those features between the item presented on the right and that presented on the left. Indeed, infants' preference for the right stimulus was correlated with the differences in leg length, $r(121) = .28$, $p < .01$, vertical extent, $r(121) = .29$, $p = .001$, and horizontal extent, $r(121) = -.22$, $p = .01$. These relations held even when the infants who were high switchers and had pets at home (i.e., those infants who categorized and learned the individual items) were excluded; for the remaining 85 infants, right preference was correlated with the difference in leg length, $r(83) = .36$, $p < .01$, difference in vertical extent, $r(83) = .37$, $p = .001$, and difference in horizontal extent, $r(83) = -.30$, $p < .01$. Importantly, even the subset of infants with pets at home and who exhibited high levels of switching and who eventually showed evidence of categorization discriminated the items: These infants' right-side preference was correlated marginally with difference in leg length, $r(17) = .40$, $p = .09$, and significantly with differences in vertical extent, $r(17) = .56$, $p < .05$, and horizontal extent, $r(17) = -.46$, $p < .05$. Thus, categorization by this group was not simply due to their inability to discriminate the items.

These significant correlations indicate that infants' looking to the two items presented on the first familiarization trial was systematically related to differences in the features of those two items—infants tended to prefer the cat with longer (or perhaps visible) legs, who were taller and less wide on the screen. These correlations do not reflect an overall preference for any one item. For example, a fluffy, orange cat standing oriented left, with its face fully visible, was clearly preferred to a sleek, black cat oriented right, also with its face fully visible. This same fluffy, orange cat was overwhelmingly the nonpreferred cat when it was paired with an orange-and-white cat sitting upright. Thus, the particular cat that was preferred changed depending on which item it was paired with. Importantly, in the context of familiarization with pairs of items, infants discriminated the items.

DISCUSSION

This study revealed the joint influence of previous experience and looking behavior on infants' learning about a collection of items. When familiarized with items from the adult-defined category of cat, only infants who had pets at home and who engaged in relatively high levels of looking back and forth between the stimuli showed evidence of having learned the collection of items. Following familiarization with 12 different cats, these infants significantly preferred a novel out-of-category item (a dog) and they significantly preferred a new cat. This is not the classic pattern that is taken as evidence of categorization (Cohen & Younger, 1983) in which within-category items are treated as equivalent. The current pattern is, however, consistent with infants having responded at the highest level of Quinn's (2002) model—they represented not only a summary of the category but also the individual items. Thus, infants who had pets at home and who engaged in relatively high levels of switching apparently had the highest level category—they remembered the individual items and they recognized the commonalities among items from within the same category. The other infants did not respond to either the category or to the individual items.

Examination of infants' looking on the first familiarization trial revealed that they discriminated the items. Infants' preference for the item on the right was systematically related to features of the items presented. Infants did not distribute their visual attention randomly to the two items, but they preferred some kinds of items over others (i.e., taller ones)—clear evidence that they noticed differences between those items and those differences contributed to their looking time. Importantly, this relation held for the group of infants who failed to respond to the category or the individual items (i.e., when the infants who were high switchers and who had pets at home were excluded from the analyses) and for the infants who eventually showed evidence of categorization. Thus, infants' responding at test was not a function of a failure to discriminate the items. Infants showed a novelty preference or failed to show a novelty preference despite the fact they could discriminate the individual items.

These results may seem surprising because many published reports have shown sensitivity to the distinction between dogs and cats at this age (Furrer & Younger, 2005; Oakes & Ribar, 2005; Quinn, Eimas, & Rosenkrantz, 1993). This apparent inconsistency may be the result of many differences between this study and previous studies—the use of one- versus two-tailed *t* tests, presenting stimuli on computer screens versus using a Fagan apparatus, different intertrial intervals, or distances between the stimuli. For example, comparing the means for entire group of infants in this experiment to chance using a one-tailed *t* test, as is often the case (French, Mareschal, Mermillod, & Quinn, 2004; Furrer & Younger, 2005; Quinn & Eimas, 1996a; Quinn et al., 1993; Quinn, Eimas, & Tarr, 2001), suggests that infants responded to the category, $M = .55$, $SD = .02$, $t(60) = 1.95$, $p < .05$, one-tailed, and marginally responded to the individual items, $M = .54$, $SD = .03$, $t(61) = 1.50$, $p = .06$, one-tailed. Thus, we would have drawn different conclusions if we had evaluated the data in this way—specifically, by 4 months infants appear to respond to the distinction between cats and dogs.

This study goes beyond this demonstration and begins to uncover the factors that influence infants' sensitivity to this distinction at 4 months. As just described, it is possible to describe these data as indicating that the group of infants as a whole responded to the category and remembered the exemplars. A deeper inspection of the data shows the responding of the subset of infants who both had a pet at home and who engaged in high levels of switching drove these effects. Thus, our results extend previous findings and suggest that what young infants learn about the kinds of stimuli used here is jointly determined by their previous experience and their online strategies for learning about and attending to those stimuli.

Moreover, although 3- to 4-month-old infants responded to the distinction between cats and dogs in a number of studies, the literature as a whole indicates that at this age infants' attention to this distinction is extremely fragile, and highly influenced by features of the stimuli and task. Oakes and Ribar (2005), for example, found that 4-month-old infants responded to this distinction when stimuli were presented in pairs, but not when the stimuli were presented one at a time. French et al. (2004) observed that 3- to 4-month-old infants' attention to this distinction is highly dependent on the level of within-category similarity. Interestingly, many studies showing this sensitivity in 3- to 4-month-old infants have used items drawn from exactly the same set of stimuli (Furrer & Younger, 2005; Mareschal, French, & Quinn, 2000; Mareschal, Quinn, & French, 2002; Quinn & Eimas, 1996a, 1996b; Quinn et al., 1993; Quinn et al., 2001; Vidic & Haaf, 2004). Thus, young infants' attention to the distinction between dogs and cats may not be as robust as it at first appears. The results reported here are consistent with this literature, and add to our understanding of the factors that contribute to infants' sensitivity to any categorical contrast in visual familiarization tasks.

These results also are consistent with two other trends in the general infant cognition literature. First, these results confirm that infants' experience outside the laboratory plays a role in their responding in the laboratory (Bar-Haim et al., 2006; Kelly et al., 2007; Kelly et al., 2005; Quinn et al., 2002). Our results extend these previous findings by demonstrating that knowledge acquired outside the laboratory can influence infants' learning in the laboratory even when they do not have the kind of extensive experience that they have with human faces. Anecdotally, a number of parents insisted that despite the fact that they had at least one indoor pet, their 4-month-old infant never attended to that animal. Despite their parents' perceptions, the pets at home did influence how the infants in our sample responded.

Of course, it is unknown precisely how infants brought their experience to bear on their learning of the items in this task. Indeed, prior experience with cats in particular did not influence infants' learning of the cats in our task. Rather infants' experience with a cat or dog at home seemed to influence their learning of the cats in the same way. So, how exactly did infants' experience with pets influence their learning? One possibility is that familiarity with four-legged, furry animals with tails may allow infants to learn more efficiently and effectively about new four-legged furry animals with tails. Rather than using detailed memories of their own specific dog or cat to learn about the images presented in the lab, experiences with dogs and cats at home may have created a general visual expectation. Pet experience may influence infants' categorization for and memory of instances of any animal (or four-legged animal).

Indeed, Westermann and Mareschal (2006) recently compared how fast networks habituated in a categorization task that included cats. Networks familiarized with various categories including animals habituated faster than did networks with similar previous knowledge that did not include animal categories. Importantly, the networks benefited from any animal category knowledge (i.e., dogs, birds, and horses) not only the animals used in the categorization task (cats). These networks, therefore, extracted some general statistical regularities of animals that could be used when encountering new kinds of animals—the infants in our investigation may have used their previous pet experience in this same way.

This work should be compared to the Westermann and Mareschal (2006) study with caution. Differences in experience (i.e., infants had exposure to one or two pets at home, whereas the networks had experience with multiple animals), methods and measures (habituation vs. novelty preference), and the similarity between previous experience and testing all may limit the comparisons that can be drawn. For example, items are presented to neural networks in the same way during the prehabituation experience and habituation itself. The infants in our experiments, in contrast, likely had very different experience at home with their pets from their experience in the lab (i.e., they likely do not see static images of their pets for 15-sec intervals). However, the fact that general experience with animals seemed to have the same influence on performance by neural networks and infants does inform us about the possible kinds of explanations for this effect, and provides a direction for future research.

An alternative possibility for why infants with pets responded differently from infants without pets is that infants with pets may be generally different from infants without pets. Parents with pets may treat their infants differently than do parents who do not have pets, and as a result infants differ in their attention and learning in general. Other data from our lab, however, show that infants with a pet at home and those who do not have pets at home respond similarly on some tasks. In a study of infants' memory for colored, oriented bars with a separate sample of 4-month-old infants ($N = 33$, M age = 125.45 days, $SD = 7.38$; 17 boys and 16 girls) tested at the University of Iowa, in the same laboratory setting, we found no effect of pet experience on responding. Following familiarization with identical pairs of stimuli (e.g., an orange vertical bar over a blue horizontal bar), we tested infants' preference for a changed stimulus (e.g., a blue vertical bar over an orange horizontal bar). We found no effect of pet status, level of switching, or the combined factors on infants' preferences, all Fs < 1.37. As a group, infants preferred the changed stimulus, exhibiting a significant novelty preference that was greater than chance, $p < .001$. Thus, pet experience did not influence performance in this task, consistent with the conclusion that the effect of pet experience on infants' learning of cats here was not due to general differences between infants with pets and infants without pets.

Obviously, without direct manipulation of experience, it is impossible to ever definitively conclude why an experiential variable does or does not influence infants' performance. In this study examining infants' memory for colored, oriented bars, the group as a whole showed a novelty preference (although they clearly were not at ceiling), so it is possible that the benefit for the pet/high switching group would have emerged on a different, more difficult task. This interpretive problem will be true for any task in which either all or none of the groups showed a novelty preference. A full understanding of how infants' previous experience influences their learning in the laboratory will involve continuing to examine differences between infants with pets and infants without pets on their learning of animals as well as experimentally manipulating infants' experiences to isolate the effect of experience.

These results also suggest an influence of infants' looking behavior during familiarization on their performance. As previously observed by Johnson et al. (2004) and Jankowski et al. (2001), infants' looking during familiarization (in our case the number of times infants shifted their gaze from one picture to the other) predicted how they responded during tests. These effects may reflect the influence of individual differences in speed of processing on learning. Other studies have shown that infants who exhibit shorter individual looks are more sophisticated in their learning than are infants who exhibit longer individual looks (Colombo et al., 1991; Freeseman, Colombo, & Coldren, 1993). Recall, however, that although the number of switches was correlated with the duration of individual looks, novelty preference scores did not seem to be related to whether infants had relatively long or relatively short looks.

Alternatively, our results may reflect individual differences in infants' active comparison of the items on their learning. When people compare items, they generally form deeper insights into the structure of a category not otherwise noticed (Gentner & Namy, 1999). In the context reported here, infants who engaged in more glancing between the two items present may have compared those items more. Indeed, other studies have shown that infants attend to more exclusive categorical distinctions when items are presented in pairs, as opposed to one at a time (Kovack-Lesh & Oakes, 2007; Oakes & Ribar, 2005; Reznick & Kagan, 1983; Younger & Furrer, 2003). Of course, because this observation is correlational (we grouped infants based on their own spontaneous comparison rate), it is premature to draw causal conclusions about how online switching influences infants' categorization. Future research, perhaps using a procedure like that used by Jankowski et al. (2001), is needed to draw causal conclusions about switching behavior and categorization.

Importantly, only previous experience and looking behavior combined influenced 4-month-old infants' category learning in this experiment. Such findings contribute to a general view of categorization and learning during familiarization as determined by the interaction of multiple factors unfolding over time (Jones & Smith, 1993; Schöner & Thelen, 2006; Smith, 2000). For example, Jones and Smith (1993) argued that categories are emergent, dynamic products of multiple sources of information. Schöner and Thelen (2006) argued that behavior in habituation is a time-dependent process, and that multiple factors will contribute to infants' looking (or not looking) at any moment. Here we have shown that infants' preferences for novel stimuli following familiarization can be jointly determined by long-term developmental processes (previous experience with pets) and individual differences in how they approach the task. Although we have not identified all of the causes of infants' preferences, we have shown that multiple factors can work together to determine what infants learn.

In summary, results like those reported here reveal insight into the processes of categorization in infancy. Clearly, even in visual familiarization tasks, categorization is complexly determined by the interaction of multiple factors. Moreover, infants' experience outside the laboratory can have a profound influence on how they respond to tasks in the laboratory. In terms of categorization, however, ultimately factors that contribute to infants' ability to effectively compare instances will determine exactly what they learn during familiarization.

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