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Contributions of attentional style and previous experience to 4-month-old infants' categorization

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Abstract

We examined how infants' categorization is jointly influenced by previous experience and how much they shift their gaze back-and-forth between stimuli. Extending previous findings reported by Kovack-Lesh, Horst, and Oakes (2008), we found that 4-month-old infants' (N = 122) learning of the exclusive category of *cats* was related to whether they had cats at home and how much they shifted attention between two available stimuli during familiarization. Individual differences in attention assessed in an unrelated task were not related to their categorization. Thus, infants' learning is multiply influenced by past experience and on-line attentional style.

In the last several decades, mounting evidence suggests that very young infants are capable of quickly learning categories of objects in laboratory tasks (e.g., Bomba & Siqueland, 1983; Quinn, Eimas, & Rosenkrantz, 1993). A number of findings converge on the idea that how infants perform in such categorization tasks is driven in large part by the perceptual characteristics of the stimuli (Kovack-Lesh & Oakes, 2007; Oakes, Coppage, & Dingel, 1997; Quinn, et al., 1993) raising the possibility that they are learning these categories online. Research has addressed this issue by asking whether such categorization is related to the kinds of knowledge structures infants develop about the world prior to laboratory experience. In contrast to a purely perceptual account, this work suggests that infants' categorization differs depending on their previous experience (e.g., Kovack-Lesh, Horst, & Oakes, 2008; Pauen, 2002; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002).

For example, infants' on-line learning of categories is shaped by pre-existing knowledge (e.g., Bornstein & Mash, 2010). Kovack-Lesh et al. (2008) found that only 4-month-old infants with pet experience showed sensitivity to the exclusive category of *cats* (i.e., one that excluded *dogs*). Moreover, even in this group only infants who had high levels of looking back and forth to the two images of *cats* simultaneously presented on each familiarization trial (i.e., "high switchers") were sensitive to the category. These findings raise the question of why learning would be determined by the interaction between the attentional processes like switching and infants' knowledge.

Kovack-Lesh et al.'s (2008) switching measure corresponds to what Rose and colleagues' have termed *shift rate*, which presumably reflects the level of active comparison among stimuli (Rose, Feldman, & Jankowski, 2002, 2003). This behavior appears to be directly related to what infants learn during a task. For example, Jankowski, Rose, and Feldman

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(2001) induced long lookers, as identified during a pretest, to perform like short lookers by encouraging them during learning to produce short glances to different stimulus regions. These “guided” long lookers had enhanced performance on a visual recognition memory task. Thus, more switching resulted in better learning.

The primary question we asked here is whether the effect of switching on learning reflects very general and stable individual differences, or whether this effect arises from differences in infants’ in-the-moment response to specific stimuli. In the first case, attentional differences (or level of switching) will predict learning regardless whether infants are assessed during a pretest using unrelated stimuli or during the task itself. This is exactly what is observed in studies of visual recognition memory (e.g., Freeseman, Colombo, & Coldren, 1993). In contrast, if switching reflects an in the-moment response to specific stimuli, then only switching during the learning task will predict the outcome. This hypothesis is supported by findings that switching is stimulus sensitive (Ruff, 1975): Infants tended to shift more between two similar stimuli (e.g., two striped stimuli) than between two dissimilar stimuli (e.g., a bull’s-eye stimulus and an array of stripes).

Either way, this leaves open the question of why switching interacts with previous knowledge to determine learning. One possibility is that infants simply learn differently about more and less familiar stimuli. Indeed, infants visually scan faces differently when the faces are from their own familiar race than those from a different unfamiliar race (Liu, et al., 2011). It is therefore possible that more familiar stimuli elicit more effective perceptual strategies than do less familiar stimuli. Alternatively, learning strategies may be more effective when applied to more familiar stimuli. That is, infants may apply the same learning strategies to familiar and unfamiliar stimuli; those strategies may help infants more when the stimuli are familiar. Indeed, Kovack-Lesh et al. (2008) found equivalent levels of switching overall by infants with and without pet experience, but high levels of switching produced a more robust effect on learning by infants who had pets. Thus, it appears that when applied, switching is more effective at influencing the learning of relatively familiar stimuli. Regardless of which of these possibilities captures the relation between switching and knowledge, it is important to determine whether switching is a general trait or a specific response a particular set of stimuli. This is the primary goal of this investigation.

We conducted a two-part study. Four-month-old infants with and without pets first were assessed for attentional style (switching, look duration) in a pretest identical to Jankowski et al. (2001), using a pair of abstract stimuli. We used this pretest because (1) Jankoswki et al. (2001) demonstrated the effectiveness of this task at predicting later learning, and (2) our goal was to determine whether individual differences in switching reflected a very general approach, thus we sought to use a pretest that differed considerably from our familiarization task. Consistency across these two contexts would provide strong evidence that switching reflects very general individual differences.

Next, infants were tested for their sensitivity to the exclusive category of *cat* using a standard familiarization-novelty preference task (see Kovack-Lesh et al., 2008), as our prior work has shown that this task is sensitive to the confluence of switching and background knowledge. In this task, infants were first familiarized with 12 exemplars of cats, two presented on each of six familiarization trials, and then their looking at a novel cat and a novel dog was compared. We also used two sets of stimuli to test whether infants’ switching —and the ultimate effect such switching has on categorization—depends on the nature of the stimulus set. Because the structure of the category can have effects on infants’ category formation (French, Mareschal, Mermillod, & Quinn, 2004; Mareschal, Quinn, & French, 2002; Quinn, et al., 1993), across subjects we manipulated the animals’ *pose*, which is irrelevant to the structure of the category but may affect how similar the stimuli are and more importantly, how easily they can be compared.

Method

Participants

The final sample was 122 4-month-old healthy, full-term infants (*M* = 126.07 days, *SD* = 7.08; 73 boys). Forty-four infants had experience with cats (typically a pet cat in the home), allowing us sufficient power to test the effect of experience with cats on infants' categorization of cats. Recruitment procedures and sample demographics were the same as in Kovack-Lesh et al. (2008). An additional 58 infants were excluded because they did not complete all trials ($n = 32$), looked ≥ 95% to one side ($n = 1$), experimenter error ($n = 1$), parental interference ($n = 1$), or looked to only one stimulus during test ($n = 27$)1.

Stimuli

The pretest stimulus was a digitized version of Jankowski et al.'s (2001) pretest stimulus (subtending approximately 27° × 56° at 40 cm viewing distance, see Figure 1A). The stimuli for the *categorization* task were digitized photographs of 24 cats and 24 dogs, (subtending approximately 21° × 27° visual angle at 40 cm viewing distance), varying in breed, coloring, and pose (see Figure 1B). In the *same pose* set, all animals were standing and faced to the right.

Procedure and Apparatus

The experiment was run in two phases, both run using Habit (Cohen, Atkinson, & Chaput, 2000). During *pretest*, infants sat on a parent's lap in a dimly lit room, approximately 40 cm from a black curtain, obstructing the infants' view of the equipment and observer, with a hole revealing a 34" (86.4 cm) monitor. When the infant looked at an attention-getter (a looming grey circle centered on the screen accompanied by a whistle), an experimenter pressed a computer key to stop the attention-getter and initiate presentation of two identical black and white patterns on the monitor (center-to-center distance: 60 cm) for each of two 15-s trials. The experimenter observed the infant via a low-light TV camera located directly below the monitor, and recorded online the infant's looks to the left or right image.

The *categorization* task was administered following a 3–5 min break (the first 15 infants did not receive a break; preliminary analyses revealed no significant differences between infants who did and who did not get a break, but attrition was improved with the break). This task was conducted in a separate room with the same set-up as the pretest except there were two 17" (43.2 cm) CRT computer monitors (center-to-center distance: 52 cm). When the infant looked at an attention-getting stimulus (a beeping sound and a blinking LED light emitting from a small box positioned midway between the two monitors), the experimenter pressed a computer key to initiate a trial. The six 15-s familiarization trials were first: On each, two different cats were presented (one on each monitor), for a total of 12 different cats presented across familiarization. The two 10-s test trials were next: On each, a novel cat was paired with a novel dog (left-right position counterbalanced across trials). Across infants, each cat stimulus was presented approximately equally frequently during familiarization and test.

[1]It is typical to excluding infants who do not compare at test (Furrer & Younger, 2005; Mareschal, French, & Quinn, 2000; Mareschal, et al., 2002; Oakes & Kovack-Lesh, 2007; Quinn & Eimas, 1996a, 1996b, 1998; Quinn, Eimas, & Tarr, 2001). It is unknown exactly why here adopting this procedure yielded a higher attrition rate than typically seen; it may be related to the fact that this was the second task conducted in the session.

To establish the reliability of the on-line recording of infants' looking and switching, a second trained coder re-recorded the looking for about 25% of the infants. The correlations between the two observers were high for the duration of looking on each trial, $r \geq .96$ (mean absolute difference between observers for look duration $M \leq .57$) and number of switches on each trial, $r \geq .86$ (average difference between observers for the number of switches $M \leq .68$).

Stimulus Validation

We validated our stimuli by presenting a separate group of 16 4-month-old infants with a two-alternative preferential looking task in which a dog and cat were presented on each of six 10-s trials (different animals were used on each trial, left/right position counterbalanced). An average cat-preference score was calculated by dividing looking to the cats by looking to the cats and dogs combined ($M = .48$, $SD = .10$) and did not differ from chance overall, $t(15) = .62$, $p > .05$. Cat preference was similar for infants with ($M = .50$, $SD = .13$) and without ($M = .48$, $SD = .10$) cats, $t(14) = .63$, $p > .05$.

Next, we tested discrimination of the individual cats by familiarizing an additional group of 16 4-month-old infants with 2 different cats, presented side-by-side, over six 15-s trials (left/right position counterbalanced). During test in which a novel cat and a familiar cat were presented side-by-side on two 10-s trials, infants preferred the novel cat ($M = .64$, $SD = .22$) significantly greater than chance, $t(15) = 2.59$, $p = .02$, $d = .90$. Preference scores were similar for infants with ($M = .67$, $SD = .29$) and without ($M = .63$, $SD = .19$) cats, $t(14) = .31$, $p > .05$.

Results

Our on-line coding generated a record of overall duration of looking and number of looks to the left and right stimulus during each trial. From this record, we calculated the number of switches by determining the number of times during each trial the infant looked from one monitor to the other, even if this switch was separated by a look away from the two monitors (i.e., to the ceiling).

Behavior during pretest and familiarization

Our first analysis asked if the basic looking pattern in pretest and familiarization was affected by the stimulus set or the infants' background (see Table 1). During *pretest*, infants with and without cats had approximately the same number of switches, $t(120) = 1.51$, and mean length of peak look, $t(120) = .41$. Thus, infants' experience with cats did not relate to differences in their visual attention to an abstract geometric stimulus.

Next, we analyzed the *familiarization phase* of the categorization task. We conducted separate Analyses of Variance (ANOVA) on the number of switches and the duration of looking in each block of 3 familiarization trials with block (1, 2) as the within-subject factor and Cat group (Cat /No-Cat), Gender (Male /Female), and Pose (Same /Variable) as between-subject factors. The analysis of switching revealed only a main effect of block, $F(1, 114) = 12.32$, $p = .001$, $\eta_p^2 = .10$; infants switched more in block 1 than in block 2, a habituation effect. There were no significant effects of cat group or pose, Fs < 1, suggesting that switching during familiarization was uninfluenced by our primary experimental factors including the animals' pose, and familiarity.

The ANOVA on look duration revealed a significant block by cat group interaction, $F(1, 106) = 7.72$, $p < .01$, $\eta_p^2 = .06$ (see Table 2). Infants with cats slightly increased looking from block 1 to block 2 whereas infants without cats slightly decreased looking from block 1 to block 2; neither change reached conventional levels of significance, ps ≥ .10. Thus, although there were differences in processing as a function of cat experience, neither group exhibited a dramatic change in looking across familiarization. Infants' attentional style during familiarization therefore was not dramatically affected by their prior experience.

Relation between pretest and familiarization

Our next analysis examined the relation between attention during pretest and familiarization. Infants' attention during these tasks was not strongly related; correlations between the number of switches, $r(120) = .12$, and peak look duration, $r(120) = .12$, were not significant. However, a modest relation was uncovered when we grouped infants using median splits of the average number of switches per trial during pretest ($Md = 5.0$) and familiarization ($Md = 2.75$) (see Table 3). Infants tended to be high (or low) switchers both during pretest and familiarization, $\chi^2(1) = 3.98$, $p = .05$. In contrast, no such relation was observed when classifying infants based on *peak look duration* during pretest and switching during familiarization, $\chi^2(1) = .13$, $p > .05$. These effects did not reflect age differences, as infants in these groups did not differ significantly in age, except that short lookers were slightly older ($M = 127.45$ days, $SD = 6.68$) than were long lookers ($M = 124.74$ days, $SD = 7.25$), $t(120) = 2.14$, $p = .03$, $d = .39$. Thus, although infants' responding in the two tasks was not strongly correlated, our dichotomous classification showed some correspondence between the two tasks.

Infants' responding during test

Finally, we examined categorization. Prior work with this task has shown that both looking behavior and previous experience jointly influenced learning (Kovack-Lesh, et al., 2008). Our primary question here was whether using the pretest as a measure of switching yields a similar pattern as using familiarization trials; secondarily we also wanted to examine the effect of pose on this pattern. We calculated infants' *novelty preference* score by dividing looking during the test to the novel dog by their total looking to the novel cat and dog. Infants were categorized as high- or low-switchers in three ways: 1) on the basis of *switching* during familiarization; 2) on the basis of *switching* during pretest, and 3) on the basis of *peak look* during pretest. This allowed us to determine whether any observed relation reflects the influence of a general strategy on categorization, or something specific to infants' strategy when learning a specific set of categorically related stimuli. Figure 2 shows the mean novelty preference scores as a function of cat ownership and switching classified each of the three ways. It is immediately apparent that when dividing infants based on their switching during familiarization, only infants who both had cats at home and who engaged in high levels of switching during familiarization had novelty preference scores above chance, thus replicating Kovack-Lesh, et al. (2008). Figures 2B and 2C show that this pattern was not obtained when infants' attentional strategy was assessed in a separate task. In these figures, it is clear that many individual infants in each group responded to the category (i.e., they had relatively high novelty preference scores), but none of the groups had an average novelty preference score (the line bisecting the bar) that was different from chances, and the 95% confidence intervals for each group (the upper and lower bounds of the bars) included the chance level of .50.

These impressions were confirmed by three separate ANOVAs conducted on infants' novelty preference with Gender, Cat-group, Pose, and Switch-group as between-subjects factors. The ANOVA classifying infants as high or low switchers during familiarization revealed only the predicted cat-group by switch-group interaction, $F(1, 106) = 6.67$, $p = .01$, $\eta_p^2 = .06$.[2] None of the other effects, including Pose, were significant, all *p*s > .15. To probe

[2]This interaction was also significant when evaluating infants' responding as a function of *pet* of any type, $F(1, 106) = 3.84$, $p = .05$, $\eta_p^2 = .03$.

the significant interaction further, we conducted two-tailed t-tests comparing the means, using a criterion of $p \leq .025$ for significance to control for multiple comparisons. Infants in the Cat/High-Switching group had novelty preference scores significantly greater than the Cat/Low-Switching group, $t(42) = 2.44$, $p = .02$, $d = .74$, and marginally greater than the No-Cat/High-Switching group, $t(59) = 2.14$, $p = .04$, $d = .57$. None of the other comparisons were significant.

Neither of the other two ANOVAs revealed significant attention by pet group interactions, confirming our impression that the groups created by crossing cat experience with median splits of our attention measures did not respond differently to the category. It must be mentioned that the analysis comparing infants based on *switching* during pretest did reveal a significant gender by switching-group interaction, $F(1, 106) = 5.78$, $p = .02$, $\eta_p^2 = .05$. Boys who were high-switchers had higher novelty preference scores than did low-switching boys, and girls showing the reverse pattern. It is not clear how this interaction relates to our main hypothesis.

We next compared the novelty preference score to chance (.50) for each of the four groups created by crossing switching level during familiarization and cat experience using two-tailed t-tests. Only infants in the Cat/High Switching group responded to the novel item significantly more than chance, $t(20) = 2.35$, $p = .03$, $d = .74$. Comparisons to chance for the other three groups were not different from chance, *p*s > .29.

The results thus far suggest that switching in-the-moment interacts with previous experience to determine categorization. To probe further whether infants who were the most stable switchers (i.e., those who were high switchers in both tasks) categorized differently from the other groups, we created groups of infants based on switching behavior on *both* pretest and familiarity (see Table 4). Although our numbers are too small for a full analysis, these means reveal that those infants with who exhibited high levels of switching both during pretest and familiarization *and had experience with cats* had the highest novelty preference during test. Indeed, in this conservative analysis, only infants in this group had a novelty preference score greater than expected by chance, $t(10) = 3.35$, $p = .007$, $d = 1.01$. Interestingly, infants without cats, who were high switchers at pretest and low switchers during familiarization also had a higher, although nonsignificant, novelty preference at test3. This last set of comparisons provides a suggestion that although infants' contextually-dependent switching may be the best predictor of their categorization, a stable underlying trait that causes some infants to be higher switchers *in general* may also contribute to the pattern observed.

Discussion

These results provide insight into the nature of attentional strategies that interact with pre-existing knowledge to determine infants' categorization. When familiarized with either of two sets of images of *cats* characterized by different levels of variability in the non-criterial feature of *pose*, only 4-month-old infants that had cats at home *and* engaged in high levels of switching between the stimuli during learning showed evidence of having recognized the exclusive category of *cat*. Thus, we replicated Kovack-Lesh et al.'s (2008) main finding, Interestingly, we did not replicate Ruff's (1975) observation that stimulus characteristics contributed to switching behavior as pose had no effect on familiarization or test. It is possible that infants were already compensating for pose in their perceptions of these figures, or that switching represents too coarse a measure to detect such effect – an analysis of actual fixations may be helpful in clarifying this.

[3]The same pattern did not emerge when crossing switching during familiarization with peak looking.

Our most important question concerned the nature of the individual differences in attention and how they lead to learning. Here, we found that switching during *learning*, but not looking behavior in an unrelated pretest, predicted infants' categorization. Thus, switching may not reflect a very general individual difference that infants apply to a wide range of tasks. Rather, it reflects the strategy infants adopted *during learning itself*, and this in turn interacted with their previous experience to contribute to categorization. Interestingly, while this strategy was specific to learning it is not entirely driven by the stimulus as pose had no effect. This suggests that there may be some stable individual differences (at this more specific level) that contribute to performance.

The difference between measures of switching may reflect the fact that infants' switching during familiarization and their novelty preference might both reflect the processes of categorization. Recall that Rose and colleagues argue that switches are a measure of *comparison of stimuli* (Rose, et al., 2002, 2003). Thus, switching during familiarization may be a function of infants' active comparison and search for commonalities among items, and infants' novelty preference during test may reflect their recognition of differences between the novel and familiar category.

Interestingly, this relation only held for infants who had pets at home, suggesting that comparison during familiarization is only related to detection of difference during test when infants have existing experience and knowledge related to the domain. Thus, learning strategies may be more effective for relatively familiar stimuli. It is important to point out that this effect may be a function of the particular category used, in this case *cat* versus *dog*. Experience and knowledge may be important for the relation between behavior during familiarization and test for recognizing this type of distinction, e.g., a basic-level distinction in which the items can easily be combined into a single, higher level category such as four-legged animal. Experience with pets may be less important when making other distinctions, such as between categories like *animal* and *vehicle*, that differ both in their level in the hierarchy (e.g., superordinate vs. basic) and in their degree of gross perceptual similarity. Thus, categorization in infancy appears to be complexly determined by on-line processes, such as comparison, the nature of the category to-be-learned, and the infants' previous experience.

These results might seem to conflict with other findings that attention during pretests like we used here predicted learning and attention on subsequent tasks (e.g., Colombo, Mitchell, Coldren, & Freeseman, 1991; Jankowski, et al., 2001). Although the pretest we used has been effective in previous studies, its relationship to the familiarization task differed in potentially important ways. In previous studies the stimuli are similar across tasks (see, e.g., Jankowski, et al., 2001); while in our study, the stimuli were quite different. Attention strategies may be restricted to a narrow range of stimuli, and the two sets of stimuli used here may have been too different to reveal consistency. Second, while previous studies used pairs of identical stimuli or a single stimulus during both pretest and familiarization (Freeseman, et al., 1993; Jankowski, et al., 2001; Stoecker, Colombo, Frick, & Allen, 1998), our pretest used pairs of identical stimuli during pretest, and pairs of different stimuli on familiarization trials. Infants' attentional strategies might differ when examining one stimulus and when comparing two *different* stimuli, and thus better prediction may have followed from a pretest with pairs of different items. Finally, previous studies (e.g., Jankowski, et al., 2001) have shown that individual differences during pretest were related to memory and discrimination, not categorization. Unlike memory and discrimination tasks, categorization requires both memory for items and detection of commonalities between different items and may thus behave differently.

Each of these differences and possible explanations is consistent with the conclusion that infant attention—in particular switching—may reflect different underlying processes in pretest and familiarization. In other words, switching is not a general individual difference that is applied in all contexts. This in itself is an important conclusion, and suggests that switching may be context-dependent. However, there is a suggestion in our data of stability in some aspect of switching—and the cognitive processes that underlie it—across the contexts. Specifically, infants with pets who were high switchers in *both* pretest and familiarization exhibited the strongest categorization, apparently approaching very different tasks and stimuli by engaging in high levels of switching. Thus, although switching itself does not seem to be robustly related across tasks, some stable individual differences in very general strategies, such as comparison processes (Kovack-Lesh & Oakes, 2007) or speed of processing (Colombo, et al., 1991; Colombo, Mitchell, & Horowitz, 1988), may contribute to categorization. In general, therefore, these data are consistent with a model of infants' categorization in which categorization is influenced both by on-line learning processes and by skills and knowledge acquired before coming to the lab.

These results also reveal an effect of experience with *cats* on infants' categorization of them. The same general pattern of results was observed here when infants were grouped by pet-or cat-ownership, but generally stronger when we examined the effect of cats in particular. The contrast with previous findings that infants' memory for and categorization of cats was influenced by exposure to either dogs *or* cats may reflect differences in statistical power, since Kovack-Lesh et al.'s (2008) original sample contained fewer infants who had exposure to cats. However, Hurley, Kovack-Lesh, and Oakes (2010) recently found that the match between 6-month-old infants' pets and the animals presented in the lab task had subtle influences on their looking behavior, suggesting that the correspondence between the infants' pet at home and the stimuli in the lab does contribute to their learning.

In sum, formation of a category for cats was influenced by a combination of infants' previous experience with cats and their attentional strategies during familiarization. Categorization was enhanced with high levels of switching during familiarization in infants with cats and perhaps by low levels of switching by infants who do not have cats. Thus, testing materials that are close to infants' past experience may induce different visual behaviors than testing materials that are more distant from infants' past experience. Learning is clearly jointly determined both by the infants' past experience and by the learning strategy they adopt during the task itself.

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References

Bomba PC, Siqueland ER. The nature and structure of infant form categories. Journal of Experimental Child Psychology. 1983; 35:294–328.

Bornstein MH, Mash C. Experience-based and on-line categorization of objects in early infancy. Child Development. 2010; 81:884–897. [PubMed: 20573111]

Cohen, LB.; Atkinson, DJ.; Chaput, HH. Habit 2000: A new program for testing infant perception and cognition (Version 1.0). Austin: University of Texas; 2000.

Colombo J, Mitchell D, Coldren JT, Freeseman LJ. Individual differences in infant visual attention: Are short lookers faster processors or feature processors? Child Development. 1991; 62:1247–1257. [PubMed: 1786713]

Colombo J, Mitchell D, Horowitz FD. Infant visual attention in the paired-comparison paradigm: Test-retest and attention-performance relations. Child Development. 1988; 59:1198–1210. [PubMed: 3168636]

Freeseman LJ, Colombo J, Coldren JT. Individual differences in infant visual attention: Four-month-olds' discrimination and generalization of global and local stimulus properties. Child Development. 1993; 64:1191–1203. [PubMed: 8404264]

French RM, Mareschal D, Mermillod M, Quinn PC. The Role of Bottom-Up Processing in Perceptual Categorization by 3- to 4-Month-Old Infants: Simulations and Data. Journal of Experimental Psychology: General. 2004; 133:382–397. [PubMed: 15355145]

Furrer SD, Younger BA. Beyond the distributional input? A developmental investigation of asymmetry in infants' categorization of cats and dogs. Developmental Science. 2005; 8:544–550. [PubMed: 16246246]

Hurley KB, Kovack-Lesh KA, Oakes LM. The influence of pets on infants' learning of cat and dog images in the lab. Infant Behavior & Development. 2010; 33:619–628. [PubMed: 20728223]

Jankowski JJ, Rose SA, Feldman JF. Modifying the distribution of attention in infants. Child Development. 2001; 72:339–351. [PubMed: 11333070]

Kovack-Lesh KA, Horst JS, Oakes LM. The cat is out of the bag: The joint influence of previous experience and comparison on infant categorization. Infancy. 2008; 13:285–307.

Kovack-Lesh KA, Oakes LM. Hold your horses: How exposure to different items influences infant categorization. Journal of Experimental Child Psychology. 2007; 98:69–93. [PubMed: 17604048]

Liu S, Quinn PC, Wheeler A, Xiao N, Ge L, Lee K. Similarity and difference in the processing of same- and other-race faces as revealed by eye tracking in 4- to 9-month-olds. Journal of Experimental Child Psychology. 2011; 108:180–189. [PubMed: 20708745]

Mareschal D, French RM, Quinn PC. A connectionist account of asymmetric category learning in early infancy. Developmental Psychology. 2000; 36:635–645. [PubMed: 10976603]

Mareschal D, Quinn PC, French RM. Asymmetric interference in 3- to 4-month olds' sequential category learning. Cognitive Science. 2002; 26:377–389.

Oakes LM, Coppage DJ, Dingel A. By land or by sea: The role of perceptual similarity in infants' categorization of animals. Developmental Psychology. 1997; 33:396–407. [PubMed: 9149919]

Oakes LM, Kovack-Lesh KA. Memory processes and categorization in infancy. Cognition, Brain, Behavior. 2007; XI:661–677.

Pauen S. Evidence for knowledge-based category discrimination in infancy. Child Development. 2002; 73:1016–1033. [PubMed: 12146730]

Quinn PC, Eimas PD. Perceptual cues that permit categorical differentiation of animal species by infants. Journal of Experimental Child Psychology. 1996a; 63:189–211. [PubMed: 8812045]

Quinn PC, Eimas PD. Young infants' use of facial information in the categorical differentiation of natural animal species: The effect of inversion. Infant Behavior & Development. 1996b; 19:381–384.

Quinn PC, Eimas PD. Evidence for a global categorical representation of humans by young infants. Journal of Experimental Child Psychology. 1998; 69:151–174. [PubMed: 9654437]

Quinn PC, Eimas PD, Rosenkrantz SL. Evidence for representations of perceptually similar natural categories by 3-month-old and 4-month-old infants. Perception. 1993; 22:463–475. [PubMed: 8378134]

Quinn PC, Eimas PD, Tarr MJ. Perceptual categorization of cat and dog silhouettes by 3- to 4-month-old infants. Journal of Experimental Child Psychology. 2001; 79:78–94. [PubMed: 11292312]

Quinn PC, Yahr J, Kuhn A, Slater AM, Pascalis O. Representation of the gender of human faces by infants: A preference for female. Perception. 2002; 31:1109–1121. [PubMed: 12375875]

Rose SA, Feldman JF, Jankowski JJ. Processing speed in the 1st year of life: A longitudinal study of preterm and full-term infants. Developmental Psychology. 2002; 38:895–902. [PubMed: 12428702]

Rose SA, Feldman JF, Jankowski JJ. Infant visual recognition memory: Independent contributions of speed and attention. Developmental Psychology. 2003; 39:563–571. [PubMed: 12760523]

Ruff HA. The function of shifting fixations in the visual perception of infants. Child Development. 1975; 46:857–865. [PubMed: 1201665]

Stoecker JJ, Colombo J, Frick JE, Allen JR. Long- and short-looking infants' recognition of symmetrical and assymmetrical forms. Journal of Experimental Child Psychology. 1998; 71:63–78. [PubMed: 9742186]

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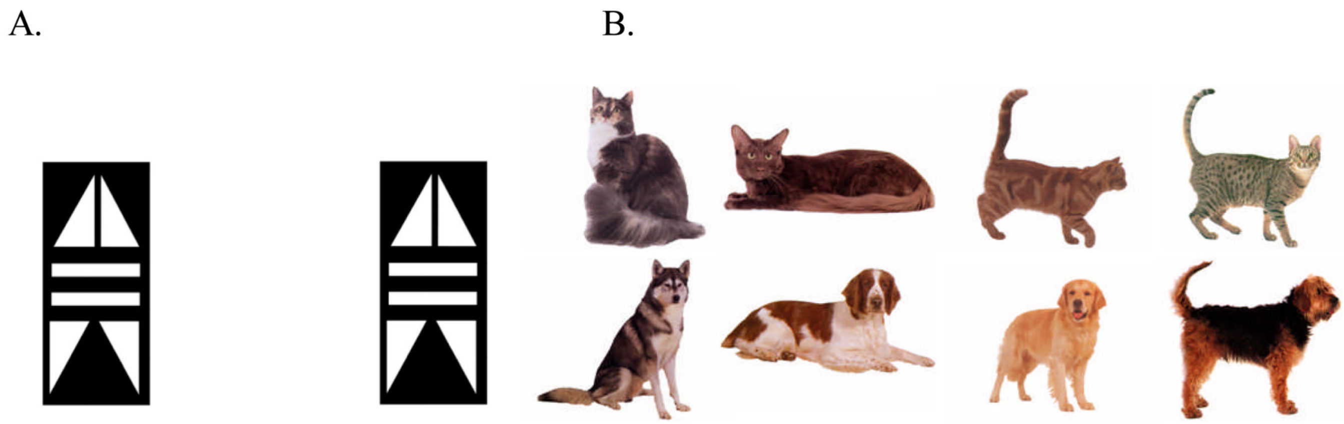

Figure 1.
A. The stimuli used in the pretest phase. These were digital images of those used by Jankowski et al. (2001). B. Examples of stimuli used during the familiarization phase.

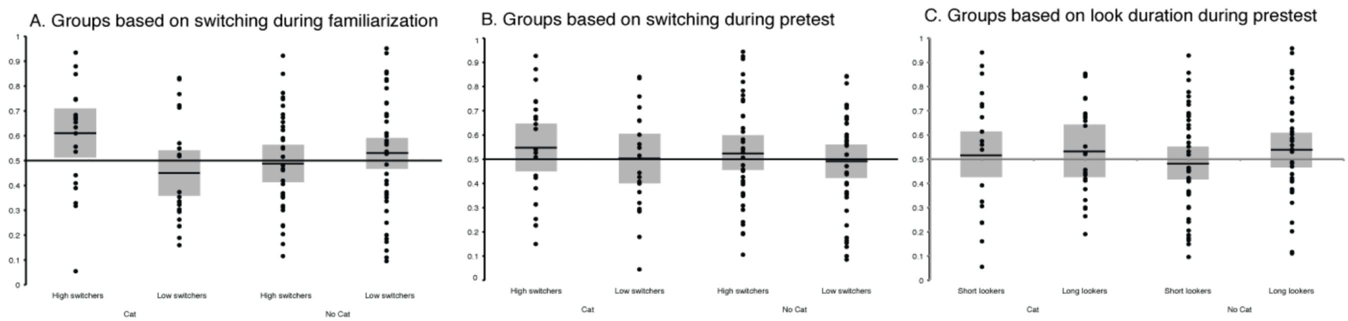

Figure 2.

Infant novelty preference scores (looking to the novel item divided by total looking during test) for Cat Group by Familiarization Switching Group (A), Cat Group by Pretest Switching Group (B), and Cat Group by Pretest Peak Looking Group (C). The box represents 95% confidence intervals; the average novelty preference score is the line bisecting the box. Each individual diamond represents the responding of a single infant.

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Table 1

Average number of switches and peak look (in s) during pretest for infants with and without cats at home.

Group	*N*		Peak Look	Number of switches
Overall	122	Mean (SD)	3.38 (2.04)	5.31 (3.03)
		Range	.9–14.2	0–18.5
Cat	44	Mean (SD)	3.48 (1.7)	4.76 (2.25)
		Range	.9–9.9	.5–11.5
No Cat	78	Mean (SD)	3.32 (2.22)	5.62 (3.37)
		Range	.9–14.2	0–18.5

Table 2

Duration of average looking (in s) and number of switches in the first block (trials 1–3) and second block (trials 4–6) during familiarization

Group	N	Looking time		Number of switches	
		Block 1	**Block 2**	**Block 1**	**Block 2**
Overall	122	9.14 (2.51)	9.11 (3.13)	3.13 (1.79) range: 0–10	2.61 (1.53) range: 0–8.67
Cat	44	9.13 (2.65)	9.74 (3.04)	2.99 (1.73) range: .33–10	2.70 (1.58) range: 0–8.67
No Cat	78	9.15 (2.45)	8.75 (3.15)	3.20 (1.84) range: 0–6.67	2.56 (1.51) range: 0–7.67

Table 3

The correspondence between classification during familiarization as high or low switcher and classification pretest as high or low switcher or as short or long looker (based on peak look duration).

		Pretest			
		Number of Switches		Peak Look Duration	
		High Switching	Low Switching	Short Lookers	Long Lookers
Familiarization	High Switching	38	23	29	32
	Low Switching	25	36	31	30

Table 4

Average novelty preference for infants based on cat group, pretest group, and familiarization group.

Pretest Measure	Cat Group	Pretest Group	Familiarization Switching	
			Low	High
Switching	Cat	Low	.48 (.21) N = 12	.54 (.25) N = 10
		High	.42 (.22) N = 11	.67 (.17) N = 11
	No Cat	Low	.49 (.23) N = 24	.51 (.20) N = 13
		High	.60 (.25) N = 14	.49 (.19) N = 27