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Development of Category Formation for Faces Differing by Age in 9- to 12-month-olds: An Effect of Experience with Infant Faces

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Abstract

We examined category formation for faces differing in age in 9- and 12-month-olds, and the influence of exposure to infant faces on such ability. Infants were familiarized with adult or infant faces, and then tested with a novel exemplar from the familiarized category paired with a novel exemplar from a novel category (Experiment 1). Both age groups formed discrete categories of adult and infant faces, but exposure to infant faces in everyday life did not modulate performance. The same task was conducted with child versus infant faces (Experiment 2). Whereas 9-month-olds preferred infant faces after familiarization with child faces, but not child faces after familiarization with infant faces, 12-month-olds formed discrete categories of child and infant faces. Moreover, more exposure to infant faces correlated with higher novel category preference scores when infants were familiarized with infant faces in 12-month-olds, but not 9-month-olds. The 9-month-old asymmetry did not reflect spontaneous preference for infant over child faces (Experiment 3). These findings indicate that 9- and 12-month-olds can form age-based categories of faces. The ability of 12-month-olds to form separate child and infant categories suggests that they have a more exclusive representation of face age, one that may be influenced by prior experience with infant faces.

Keywords

category formation; infant cognition; face perception; face age

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Parsing the world into structured categories is a fundamental cognitive ability that has an early onset in human infants, with even newborns displaying primitive category learning abilities (Quinn, Slater, Brown, & Hayes, 2001; Turati, Simion, & Zanon, 2003). Numerous studies have reported evidence of infant category formation for various object classes, inclusive of geometric forms, objects, and animals (reviewed in Quinn, 2011). One issue that

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has arisen in interpreting such studies is whether infant category representations are formed on-line during the course of an experimental study or whether the experiments are tapping into representations that existed prior to arrival at the laboratory and were formed either through evolutionary processes or based on real-life experience.

Faces represent a class of frequently encountered stimuli that may be especially likely to be influenced by prior experience. For example, Quinn et al. (2002) investigated gender representation in 3- to 4-month-olds and reported an asymmetry in category formation. While infants familiarized with male faces looked longer at a novel female face compared to a novel male face, they did not look longer to a novel male face compared to a novel female face when familiarized with female faces. Such behavior was subsequently linked to a spontaneous preference for female faces (Quinn et al., 2002, 2008), which in turn stemmed from an advantage in exposure to female compared to male faces (Rennels & Davis, 2008; Sugden, Mohamed-Ali, & Moulson, 2014).

Infants likewise rely on predominant experience with own-race faces to form categories of faces based on race (Anzures, Quinn, Pascalis, Slater, & Lee, 2010), and have presented an asymmetry in performance at 6 months: While infants familiarized with other-race faces looked longer at a novel own-race face compared to a novel other-race face, they did not look longer to a novel other-race face compared to a novel own-race face when familiarized with own-race faces (Anzures et al., 2010). The asymmetry presumably reflects own-race face preference (Kelly et al., 2005; Kelly, Liu, et al., 2007). However, such asymmetries in category formation seem to decline with age, both for gender (i.e., 10-month-olds, Younger & Fearing, 1999) and race (i.e., 9-month-olds, Anzures et al., 2010), a development that coincides with a downturn in the female face preference (Liu, Xiao, Quinn, et al., 2015) and the own-race face preference (Liu, Xiao, Xiao, et al., 2015). In the case of race, developmental change in category formation is also linked with more exposure to own-race faces (Rennels & Davis, 2008). For example, 9-month-old category formation for own-race faces constitutes categorization in that it is coupled with discrimination of those faces, whereas 9-month-old category formation for other-race faces more likely reflects categorical perception and comes with decreased discrimination of other-race faces, i.e., narrowing (Anzures et al., 2010; Kelly et al., 2009; Kelly, Quinn, et al., 2007).

It is entirely unknown whether infants also rely on experience to form categories of faces based on age. Studying development of category formation of faces based on age presents a unique opportunity to test several theoretically important contrasting hypotheses. A biological predisposition hypothesis suggests that infants could bring to the category formation task an already formed representation of an infant face. Humans have been theorized to be biologically predisposed to mentally represent infant faces due to a baby schema (Lorenz, 1943). Evidence consistent with a baby schema has been reported in adults (Luo, Li, & Lee, 2011), children (Sanefuji, Ohgami, & Hashiya, 2007), and infants (Geldart, Maurer, & Carney, 1999).

Juxtaposed to the possible innate representation for infant faces are findings that infants experience adult faces more frequently than other age groups (Rennels & Davis, 2008; Sugden et al., 2014). This differential exposure results in poor discrimination abilities for infant faces compared to adult faces in 9-month-olds (Macchi Cassia, Bulf, Quadrelli, & Proietti, 2014). Infants might thus have a more structured representation of adult faces compared to other-age faces due to experience.

By investigating how infants form face age categories, we can examine these contrasting hypotheses. In Experiment 1, we familiarized 9- and 12-month-olds with infant or adult faces, and then tested with a novel infant face versus a novel adult face. In Experiment 2, the same category formation task was conducted with the same age groups, but with the presumably more difficult contrast between infant and child faces. The age groups were chosen to assess infants after the developmental narrowing window. If the biological predisposition hypothesis is correct, both age groups should benefit from the baby schema by readily forming a category for infant faces that excludes both adult and child faces in Experiments 1 and 2. In contrast, if experience with adult faces enhances infant category formation of adult versus infant faces, then we would expect both age groups to readily form a category for adult faces that excludes infant faces in Experiment 1.

The experiments will also help us to evaluate an additional possible experiential influence, namely, whether perceptual experience with infant faces is able to influence category formation for differently aged faces. Although infants have less perceptual experience with infant than adult faces, because of experience with infant faces in daycare, infants in daycare may have already begun to develop a representation for the category of infant faces based on real-life experience. To investigate this issue, we included for both experiments infant participants regularly attending daycare. Such participants allow us to examine whether experience with infant faces that accrues in daycare affects how infants form categories of faces based on age. If there are individual differences in infant category formation for face age based on differential experience with infant faces, we reasoned that an increase in exposure to infant faces should result in higher novel category preference scores in Experiments 1 and 2, particularly in the tasks in which infants have to form an infant face representation, i.e., when infant faces are the familiarized category. It is also worth noting that the effect of experience with infant faces might be such that it needs to reach some threshold amount in order to impact category formation. For example, it may be necessary for an infant to be exposed to infant faces for a certain amount of time, and also be exposed to a certain number of different individual infant faces, before any influence of experience can be detected. If so, it might be more likely to be manifest in 12-month-olds relative to 9-month-olds, since 12 month-olds have more opportunity to be exposed to infant faces than 9-month-olds.

Experiment 1

Method

Participants—Thirty 9-month-olds (*M* = 286.43 days, *SD* = 4.48 days, 17 females) and 30 12-month-olds (*M* = 375.13 days, *SD* = 6.70 days, 15 females) participated. Fourteen additional 9-month-olds and 9 12-month-olds were excluded due to failure to compare the test stimuli (*n* = 10 for 9-month-olds, *n* = 7 for 12-month-olds), side bias (looking at one side of the display for 95% or more of the total looking time on both test trials, *n* = 2 for 9-month-olds), fussiness (*n* = 2 for 12-month-olds), or procedural error (*n* = 2 for 9-month-olds). All participants were exposed to infant faces through daycare as early as 3 months. Parents were asked when their infant started attending daycare and the number of days in the week they spent there. We calculated the number of days of exposure that the infant participants had with infant faces between their first day at daycare and the day of testing. Nine- and 12-month-olds were exposed to infant faces for an average of 54.57 days (range: 2-132 days) and 100.18 days (range: 8-205 days), respectively, indicating that the 12-month-olds had an average of 45.61 more days of experience with infant faces relative to the 9-month-old.

Stimuli and procedure—Stimuli were grayscale images of 28 adult (14 females) and 28 infant faces (14 females), matched for average luminance, contrast, and size. Pictures were originally in color but converted to greyscale images to neutralize chromatic differences between the pictures from the different age categories. Each image was 22 cm high and 16 cm wide, subtending 35° × 26° degrees of visual angle. Adult faces were neutral faces from the NimStim database (Tottenham et al., 2009) and our own database; infant faces were neutral faces from our own database (i.e., pictures of infants who had visited the lab in the past). Pictures were cropped so that hairstyles were fairly uniform across the stimuli. Images were presented on a gray background. Infants were tested in a quiet room and seated on a parent's lap approximately 60 cm away from a 52 × 32.5 cm monitor onto which the images were projected. Parents were instructed to fixate centrally above the screen and remain quiet during testing.

From the 56 faces (28 adult and 28 infant faces), 8 adult and 8 infant faces were paired for the test phase, matched on gender (four female pairs). The faces presented at test were one novel face from the familiarized age category and one novel face from the novel age category. Face gender (male or female) was counterbalanced between participants, so each infant only saw either male or female faces during the entire experiment (familiarization and test phase). During the familiarization phase, eight stimuli were randomly selected separately for each infant (from among the 13 remaining stimuli given that 1 stimulus was already selected for use in the test phase) and presented at the rate of two per trial (side-by-side) for four 10 s trials. For example, an infant familiarized with adult female faces was presented with 8 adult female faces selected from the pool of 13 adult female faces (i.e., all 14 adult female faces minus the face selected for use in the test phase). The face category presented during familiarization (adult or infant) was counterbalanced between participants. Immediately after familiarization, two 5 s test trials were presented. On the first test trial, the infant's first look at the images started a 5 s countdown monitored by the experimenter. At the end of the 5 s, the images disappeared from the screen. The same faces were presented on the second test trial with their left/right position on the screen reversed. On the second test trial, another 5 s countdown was initiated when the infant looked at the images. Left/right positioning of the adult/infant faces on the first test trial was counterbalanced across infants (see Figure 1). Before each trial, an attention-getter attracted infant gaze toward the screen middle. Infant fixations to the stimuli were recorded by an observer who was blind to the screen positions of the faces. The observer was positioned behind the screen, recording the looking time of the infant with a camera situated just above stimulus display, surrounded by a black background. To ensure reliability, 20% of the videos (n = 12) were coded by another observer; average level of inter-observer agreement was high (Intra-class correlation assessed for absolute agreement, ICC[2, 2] = .989).

Results and Discussion

Familiarization phase—It is not uncommon to evaluate decrease in looking time during the course of the familiarization by comparing the looking time difference between the first and the second half of the familiarization phase (e.g., Quinn, Lee, Pascalis, & Tanaka, 2016). In the present case, there were 4 familiarization trials, so the two halves of familiarization consisted of two trials each. To determine whether infants habituated to the familiarized age of faces, an ANOVA was conducted on the amount of time spent looking at the faces during Trials 1 and 2 (first half of familiarization), and during Trials 3 and 4 (second half of familiarization), of the familiarization phase. Because two faces were displayed per trial, looking time to both was summed on each trial, and then averaged on Trials 1 and 2, and on Trials 3 and 4. A mixed ANOVA with Familiarization trials (1-2 vs. 3-4) as a within-subject factor, Age category (Adult or Infant) and Participant age (9- or 12-month-old) as between-subject factors, and Exposure to infant faces (days) as a continuous variable, performed on the individual scores revealed a significant Familiarization trials effect, $F(1, 52) = 17.39$, $p < .001$, $\eta^2 = .25$ (see Table 1), with looking time declining between Trials 1-2 and Trials 3-4. The reliable decrement indicated that 9- and 12-month-olds habituated to the infant and adult faces. There was additionally a main effect of Participant age, $F(1, 52) = 4.62$, $p = .036$, $\eta^2 = .08$, and a significant Familiarization trials × Participant age interaction, $F(1, 52) = 4.43$, $p = .040$, $\eta^2 = .08$, indicating that the decrement in looking time from Trials 1-2 to Trials 3-4 was greater for 12-month-olds than for 9-month-olds. There was no significant effect of Age category ($F[1, 52] = 2.68$, $p = .108$), no effect of Exposure to infant faces ($F[1, 52] = 1.30$, $p = .260$), and no interaction with Age category or Exposure to infant faces (all p values > .22).

Test phase—To assess category formation, we computed a novel category preference for each participant by dividing looking time toward the novel category exemplar by total looking duration toward both the novel and familiarized category exemplars across both test trials, and converted this value to a percentage. One sample t-tests were conducted to compare the mean novel category preferences to chance level (50%). Results showed that 9- and 12-month-olds looked significantly longer to the novel category faces when familiarized with either adult or infant faces (see Table 1). Nine- and 12-month-olds formed a category representation for adult faces that included novel adult faces, but excluded novel infant faces, and a category representation for infant faces that included novel infant faces, but excluded novel adult faces.

To investigate the influence of exposure to infant faces on category formation, we conducted an ANOVA with Age category (infant vs. adult), Participant age (9-, or 12-month-old), and Exposure to infant faces (days) as a continuous variable, on the novel category preference scores. Results showed no significant main effect of age ($F[1, 52] = 1.83$, $p = .182$), or age category ($F[1, 52] = 1.16$, $p = .287$). The effect of exposure to infant faces on the novel category preference scores was also not significant ($F[1, 52] = 1.50$, $p = .227$). The interactions were additionally not significant (all *p* values > .26). These results suggest that increase in exposure to infant faces did not affect category formation (see Figure 2).

The findings from Experiment 1 indicated that both age groups formed categories for adult versus infant faces. There was thus no evidence for exclusive support of the baby schema hypothesis, which would have suggested that infants would display an advantage in representing infant faces. There was also no evidence for exclusive support of the adult experiential hypothesis, which would have suggested that the infants would display an advantage in representing adult faces. Finally, given the null effect of experience with infant faces, there was no evidence to support an individual differences account based on experience with infant faces. The overall pattern of results might suggest that infants were simply using on-line category learning processes (e.g., Mareschal & French, 2000). However, in addition to on-line learning processes, it could also have been the case that *both* a baby schema and adult face experience were operative, with the baby schema bolstering category formation for infant faces and the adult face experience enhancing category formation for adult faces.

Experiment 2

In Experiment 2, we further probed the abilities of 9- and 12-month-olds to form categories based on face age, and investigated category formation for infant versus child faces. Because infant and child faces are morphologically more similar than infant and adult faces, perceptual experience with infant faces might be particularly crucial to perform the presumably more difficult partitioning of infant versus child faces. Moreover, unlike adult and infant faces, child faces are unfamiliar to infants (Rennels & Davis, 2008). Therefore, infants would not be able to call on a pre-existing child face representation, unless they have one or more older siblings. Evidence for a pre-existing representation for child faces would be manifest if infants with siblings more readily formed a category representation for child faces that excluded infant faces than infants without siblings.

Method

Participants—Thirty-one 9-month-olds (*M* = 285.81 days, *SD* = 5.99 days, 18 females) and 31 12-month-olds (*M* = 375.93 days, *SD* = 5.01 days, 13 females) participated. Fifteen additional 9-month-olds and 14 12-month-olds were excluded due to failure to compare the test stimuli (*n* = 12 for 9-month-olds, *n* = 11 for 12-month-olds), side bias (*n* = 3 for 9-month-olds, *n* = 1 for 12-month-olds), or fussiness (*n* = 2 for 12-month-olds). As in Experiment 1, all infants had been exposed to infant faces through daycare. Nine- and 12-month-olds were exposed to infant faces for an average of 68.98 days (range: 12-182 days), and 96.72 days (range: 6-187.5 days), respectively, indicating that the 12-month-olds had on average 27.74 more days of experience with infant faces relative to the 9-month-olds. Exposure to child faces through older siblings could not be quantified by days of exposure, and was thus reported only as a categorical variable. Thirteen 9-month-olds and 10 12-month-olds had at least one older sibling (Mean age = 5.84 years, age range = 4-10 years).

Stimuli and procedure—Stimuli were grayscale images of 28 child (14 females) and 28 infant faces (14 females), matched for average luminance, contrast, and size. Infant faces were those presented in Experiment 1. All aspects of the procedure were identical to Experiment 1, except for the child stimuli. Child photos came from our own database (i.e., pictures of children who had visited the lab in the past). A second observer coded 20% of the videos; average level of inter-observer agreement was high (Intra-class correlation assessed for absolute agreement, ICC[2, 2] = .984).

Results and Discussion

Familiarization phase—To determine whether infants habituated to the familiarized age of faces, an ANOVA was conducted on the amount of time spent looking at the faces on Trials 1 and 2 and Trials 3 and 4 during the familiarization phase. Looking time was averaged for Trials 1 and 2, and for Trials 3 and 4. A mixed ANOVA with Familiarization trials (1-2 vs. 3-4) as a within-subject factor, Age category (Child or Infant) and Participant age (9- or 12-month-old) as between-subject factors, and Exposure to infant faces (days) as a continuous variable, was performed on the individual scores, and yielded only a significant effect of Familiarization trials, $F(1, 54) = 9.47$, $p = .003$, $\eta^2 = .15$. No other main effects (Exposure to infant faces, $F[1, 54] = 1{,}09$, $p = .301$, Age category, Participant age, both Fs < 1), nor interactions (Participant age × Age category, $F[1, 54] = 3.21$, $p = .079$, Participant age × Age category × Exposure to infant faces, $F[1, 54] = 2.54$, $p = .117$, all other Fs < 1), were significant. The decrement in looking time from the first to the second half of familiarization indicated that the 9- and 12-month-olds habituated to the infant and child faces.

Test phase—We computed a novel category preference score for each participant as in Experiment 1. To examine whether mean novel category preferences differed reliably from chance, we conducted one sample *t*-tests within each age group for each age category. Twelve-month-olds looked longer at the novel category faces when familiarized with either child or infant faces (see Table 2). Twelve-month-olds thus formed a category for child faces that included novel child faces, but excluded novel infant faces, and a category for infant faces that included novel infant faces, but excluded novel child faces. Nine-month-olds, however, presented an asymmetry, looking longer at the novel category faces when familiarized with child faces, but not when familiarized with infant faces (see Table 2). The 9-month-olds thus formed a category for child faces that included novel child faces, and excluded novel infant faces, but when familiarized with infant faces, they either did not form a category or they formed a category that included novel child faces. Such a result might seem contradictory with the results from Experiment 1, where 9-month-olds successfully formed a discrete category of infant faces when contrasted with adult faces. However, child faces are structurally closer to infant faces than are adult faces, suggesting that the child/infant category contrast would be more difficult to represent than the adult/infant category contrast. As a result, 9-month-old infants appear to be able to form separate categories for infant and adult faces, but not for infant and child faces.

To investigate the influence of exposure to infant faces on category formation for child versus infant faces, we conducted an ANOVA with Age category (Child or Infant), Participant age (9- or 12-month-old), and Exposure to infant faces (days) as a continuous variable, on the novel category preference scores. There was no effect of Age category, F(1,

54) = 2.62, $p = .111$, or Participant age, $F(1, 54) < 1$. However, the analysis did reveal a significant positive relationship between Exposure to infant faces and novel category preference scores, $F(1, 54) = 10.12$, $p = .002$, $\eta^2 = .16$, showing that novel category preference scores increased as infants received more exposure to infant faces. There were no significant interactions (all p values > .21). Despite the null interaction between Age category, Participant age, and Exposure to infant faces, further inspection of the data revealed that the effect of exposure to infant faces on the novelty preference scores was significant only for the 12-month-olds familiarized with infant faces; no other correlations reached significance (see Figure 3).

Some infants also had exposure to child faces through an older sibling ($n = 23$). Unfortunately, there were not enough infants exposed to child faces to conduct a complete analysis (i.e., including Age category, Participant age, Sibling presence, and Exposure to infant faces) because the smaller cells contained only 5 infants. However, an ANOVA with Sibling presence (yes or no), Age category (Child or Infant), and Exposure to infant faces (days) as a continuous variable, performed on the novel category preference scores revealed no effect of Sibling presence, $F(1, 54) < 1$, no effect of Age category, $F(1, 54) = 1.61$, p = .209, and no Sibling presence × Exposure to infant face interaction, $F(1, 54) = 1.73$, $p = .194$, all other Fs < 1. The effect of Exposure to infant faces was still significant, $F(1, 54) = 9.87$, $p = .003$, $\eta^2 = .15$. In addition, in the condition in which infants were familiarized with child faces, infants with siblings did not perform differently than infants not exposed to child faces (infants with siblings, $M = 57.51\%$, $SD = 13.78$, infants without siblings, $M = 60.53\%$, $SD = 10.90$, t[28] = -0.66, p = .517, two-tailed).

As was the case in Experiment 1, Experiment 2 did not provide support for the baby schema hypothesis in that neither age group of infants displayed an advantage in representing infant faces. However, Experiment 2 did provide support for an individual differences account based on differential experience with infant faces given that at least at 12 months, individual novel category preference scores were associated with greater experience with infant faces when familiarization was with infant faces. As noted, Experiment 2 also revealed an asymmetry in performance in the 9-month-olds, and in Experiment 3, we explored a possible basis for that.

Experiment 3

Experiment 2 revealed that 12-month-olds formed discrete categories of child and infant faces. By contrast, 9-month-olds formed a category representation of child faces that excluded novel infant faces, but a category representation of infant faces that included novel child faces. Asymmetries in category formation could reflect spontaneous preference for one of the categories presented (Anzures et al., 2010; Quinn et al., 2002; Ramsey, Langlois, & Marti, 2005). In the present case, a possible spontaneous preference for infant faces would have facilitated a novel category preference for infant faces after familiarization with child faces and would have interfered with a novel category preference for child faces after familiarization with infant faces. Thus, Experiment 3 was conducted to assess whether a spontaneous preference for infant faces could explain the asymmetry.

Method

Participants—Fourteen 9-month-olds (*M* = 281.43 days, *SD* = 8.03 days, 8 females) participated. Three additional 9-month-olds were excluded due to side bias (looking at one side of the display for 95% or more of the total looking time, i.e., 19 s, *n* = 1), fussiness (*n* = 1), or experimental error (*n* = 1). All infants had been exposed to infant faces through daycare.

Stimuli and procedure—Stimuli were the infant and child faces from Experiment 2. Each infant was presented with two pairs of child and infant faces. Each pair was displayed for 10 s. All the trials were included in the analyses. The particular infant and child faces for each pair were selected from among 8 possible pairings. Left-right positioning of stimuli was counterbalanced across infants on the first trial and reversed on successive trials. Each trial depicted different individuals. Presenting multiple pairs of faces allowed us to determine whether the preference is for one category over another, rather than one individual face versus another individual face. The use of multiple pairings to assess spontaneous preference for one over another category has been used in previous research on infant category formation (e.g., Eimas & Quinn, 1994). A second observer coded 60% of the videos; average level of inter-observer agreement was high (Intra-class correlation assessed for absolute agreement, ICC[2, 2] = .996).

Results and Discussion

To assess whether infants display a spontaneous preference for one versus another category, it is necessary to compute the mean preference for one of the two categories. In the present case, we computed the mean preference for infant faces by taking the sum of the looking time to the infant faces on both trials, dividing by the total looking time to the infant and child faces on both trials, and then multiplying the resulting fraction by 100 to yield a percentage score. Mean preference was 50.34% (*SD* = 9.55%), which was not reliably different from chance ($t[13] = 0.13$, $p = .89$, two-tailed). This outcome suggests that the asymmetry reported in Experiment 2 is unlikely to reflect spontaneous preference for infant faces.

General Discussion

The current study investigated whether 9- and 12-month-olds could form category representations of faces differing in age, and how perceptual experience with infant faces affected formation of these representations. Results from Experiment 1 showed that both age groups formed separate category representations for infant and adult faces. Moreover, there was no correlation between amount of exposure to infant faces and novel category preference. The findings do not support exclusive operation of a baby face schema, which would have suggested that infants would display an advantage in representing infant faces. The findings also do not support a role for adult face experience, working in isolation from other factors, which would have suggested that infants would display an advantage in representing adult faces. Lastly, the null correlation between novel category preference and amount of exposure to infant faces does not support an individual differences account based on differential experience with infant faces. It could be that the infants relied on on-line learning processes to form the categories (Bornstein & Mash, 2010; Mareschal & French, 2000). It has been shown that infants can use co-variation information between features in the familiarization stimuli to construct a category (Mareschal & Quinn, 2001; Younger & Cohen, 1986; Younger, 1990), and thus perform the task purely in a bottom-up fashion without recruiting prior knowledge of the presented categories. In addition, as mentioned previously, it could also be that multiple influences were operating simultaneously, such that infant performance with infant faces was supported by a baby schema and infant performance with adult faces was supported by experience with adult faces.

One further interpretive issue concerning the outcomes of Experiment 1 is whether the category formation process reflected categorization or categorical perception (Quinn & Eimas, 1998). The former refers to formation of discrete groups composed of similar but discriminable individuals, whereas the latter refers to formation of discrete groups of exemplars that are difficult to discriminate. Regarding discrimination, Macchi Cassia et al. (2014) reported that 9-month-olds display a downturn in discrimination of infant faces compared to adult faces. These results imply that infants in the current study engaged in categorization of adult faces and categorical perception of infant faces. However, this suggestion should be considered tentative given that our samples of infants were exposed to infant faces, which might have increased their ability to discriminate infant faces. Similar phenomenon have been reported for race, where exposure to other race-faces was sufficient to prevent or reverse perceptual narrowing in 9-month-olds (Anzures et al., 2012; Heron-Delaney et al., 2011; Spangler et al., 2013). Hence, it is difficult to be definitive about whether infants engaged in categorization or categorical perception of infant faces without further investigation of infant ability to discriminate infant faces. It should be noted, however, that either process results in the creation of a set of entities that are treated as equivalent.

Experiment 2 examined the abilities of 9- and 12-month-olds to form discrete category representations of child and infant faces, two categories less frequently encountered than adult faces, and a morphologically more similar contrast. As in Experiment 1, Experiment 2 did not provide evidence of an exclusive influence of a baby schema: the infants did not display an advantage in forming a representation for infant faces. Experiment 2 also did not reveal an effect of siblings on novel category preference, nor did it reveal an effect in which infants with siblings responded differentially in the child familiarization condition relative to infants without siblings. However, in contrast to Experiment 1, at least at 12 months, where infants formed discrete categories of infants versus child faces, exposure to infant faces had a significant impact. The more infants were exposed to infant faces, the higher was their novel category preference. Moreover, this relation was significant only in the cell where one would predict it would be significant, namely, the cell in which infants were familiarized with infant faces. That the effect of exposure was present at 12 months, but not at 9 months, is additionally consistent with experience needing to surpass a threshold amount to influence novel category preference (see Liu, Xiao, Quinn, et al., 2015, for related discussion of how experience may need to surpass a threshold amount to influence gender-based preference in infants). Note that the age difference does not imply that the crucial factor here is chronological age. Rather, consistent with the ANOVA of test trial performance in Experiment 2, our view is that it is the amount of experience with infant faces. This view is additionally in accord with the parental report data indicating that the 12-month-olds had nearly a month longer worth of day care experience with infant faces relative to the 9-month-olds.

The evidence that greater perceptual experience with infant faces facilitated forming a category for infant faces that excluded child faces at 12 months provides support for an individual differences account of infant category formation based on face age. More generally, the findings support the argument that infant category formation processes tap into experiences occurring prior to arrival at the laboratory (Oakes & Madole, 2000; Quinn, 2011). The data highlight a role for differential experience in the emergence of social categories (Anzures et al., 2010; Quinn & Eimas, 1998; Quinn et al., 2002, 2016; Ramsey, Langlois, & Marti, 2005; Younger & Fearing, 1999).

An issue of interest is why exposure to infant faces affected infant category formation in Experiment 2, but not in Experiment 1. As we noted in the Results and Discussion section of Experiment 2, because of the physical differences between adult, child, and infant faces, the adult/infant category contrast might be easier to represent than the infant/child category contrast, possibly allowing infants to rely more exclusively on on-line processes. Another possibility is related to the fact that infants receive large amounts of exposure to adult faces, regardless of whether they are exposed to infant faces. Infants may draw from this perceptual experience with adult faces to form discrete representations of adult versus infant faces. Differences in exposure to infant faces might in this case be secondary; hence, the absence of correlation between the novelty preference score and exposure to infant faces in that condition.

An additional issue of interest is why the presence of older siblings did not influence category formation by infants. One possible explanation is that siblings can vary in age, whereas the child stimuli presented to the infants were limited to 5- to 7-year-olds. Another possibility is that having one or two siblings of different ages in the home does not provide the infant with sufficient experience to build up a coherent representation of child faces. It is also possible that such a representation could develop at an older age with additional experience.

Experiment 2 also revealed evidence of developmental change whereby 12-month-olds represented infant and child faces as discrete categories, and 9-month-olds presented a more ambiguous pattern of responding. In particular, the younger infants increased looking to infant faces relative to child faces when familiarized with child faces, but did not increase looking to child faces relative to infant faces when familiarized with infant faces. Asymmetries in category formation are not uncommon, and sometimes relate to spontaneous preference for one category over the other (Anzures et al., 2010; Quinn et al., 2002; Ramsey et al., 2005). In the present case, a preference for infant over child faces based on differential experience would work in concert with a novel category preference for infant faces after familiarization with child faces, thereby producing a robust novel category preference. Likewise, a preference for infant over child faces would interfere with a novel category preference for child faces after familiarization with infant faces, and produce a null preference. However, as shown in Experiment 3, a spontaneous preference for infant over child faces does not seem to be the likely explanation here.

Another possibility is to consider an influence of both on-line learning and differences in previously acquired knowledge, as proposed by Quinn and Eimas (1998) to account for an asymmetry in the categorization of humans versus non-human animals. In that study, 3- to 4-month-old infants familiarized with humans formed a category for humans inclusive of horses, but when familiarized with horses, the infants formed a category representation for horses that excluded humans. The perceptual experience of infants with human visual stimuli might generate a global category that includes non-human animals. More generally, a more frequently experienced category may serve as an attractor for a less frequently experienced category that shares some perceptual commonalities with the more frequently experienced category. Rogers and McClelland (2004) similarly reported simulation results indicating that increased experience with a category led, *early in learning*, to a tendency to generalize the name of that category to similar but less frequently encountered categories. In our experiment, the finding that 9-month-olds habituated with infant faces generalized their looking time responsiveness to new child faces fits with this type of account, on the assumption that day care experience led the infants to experience infant faces more frequently than child faces. Also, consistent with the simulation results, the asymmetry disappeared later in learning and was no longer apparent in 12-month-olds.

More studies are needed to further investigate the influence of exposure to differently aged faces on how infants respond to different face age categories. Future studies should also examine category formation for face age in infants younger than 9 months, who are less experienced with faces from different age groups. Forthcoming lines of investigation could additionally focus on other aspects of visual perception such as face detection in complex visual arrays, contrasting categories of faces differing by age (for related work contrasting categories of faces by species, see Jakobsen, Umstead, & Simpson, 2016; Simpson, Jakobsen, Damon, Suomi, & Ferrari, in press). Such work would have theoretical significance given that infant faces have been shown to be attentionally prioritized by adults, in both humans (Brosch, Sander, & Scherer, 2007; Proverbio, De Gabriele, Manfredi, & Adorni, 2011) and monkeys (Koda, Sato, & Kato, 2013). Finding such an effect in infants without experience with infant faces would support an early influence of a baby schema. However, a recent report of spontaneous preference for adult over infant faces in a population of 3- to 6-month-old infants, who have little or no experience with infant faces, suggests an early advantage for adult faces in infants (Heron-Delaney et al., in press). Moreover, it has been shown that top-down processes are at play in perception based on a baby schema (Kaufman et al., 2013), which is consistent with a later development for the influence from such a schema. Whatever the outcomes of the prospective studies, the current findings provide evidence that infants form categories based on the age of faces and that such category formation is influenced by everyday experience with faces.

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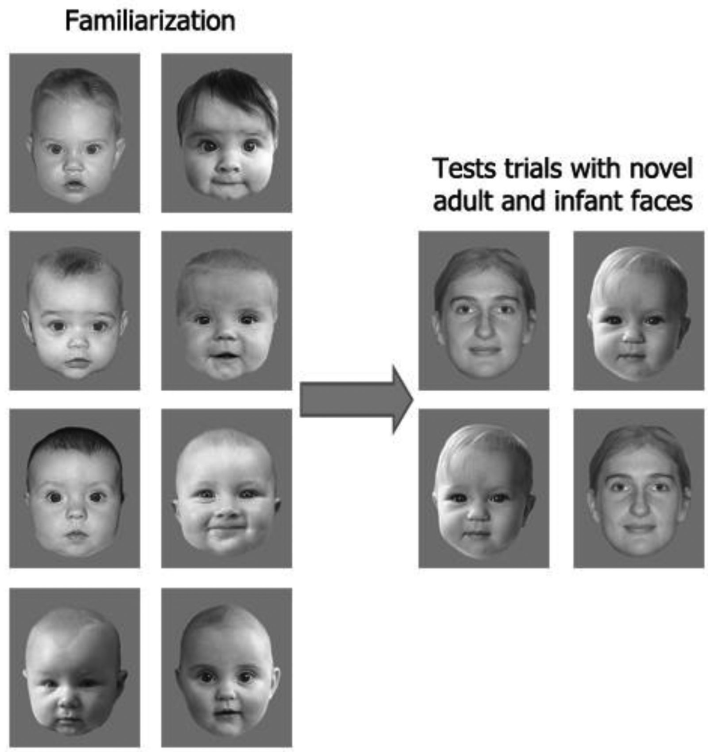

Figure 1.
Examples of the stimuli used in Study 1, condition: Infant to Adult (left: habituation trials; right: test trials).

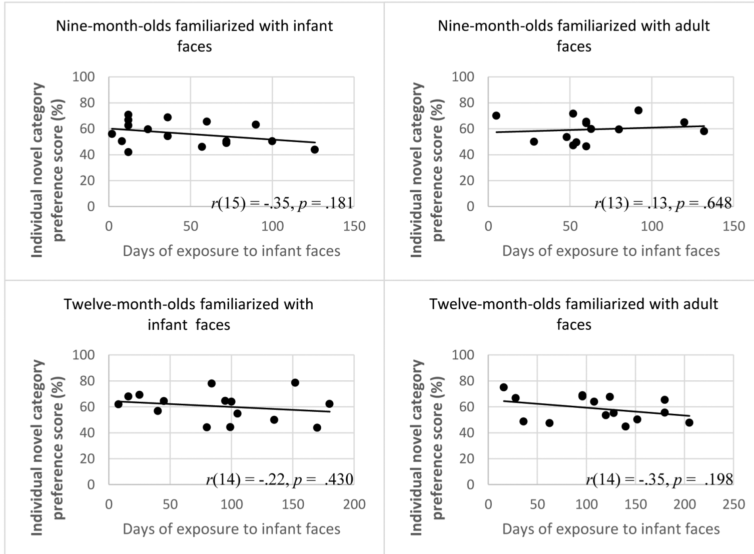

Figure 2.

Nine- and 12-month-old correlations between individual novel category preference scores and the number of days of exposure to infant faces for the infant and adult face familiarization conditions.

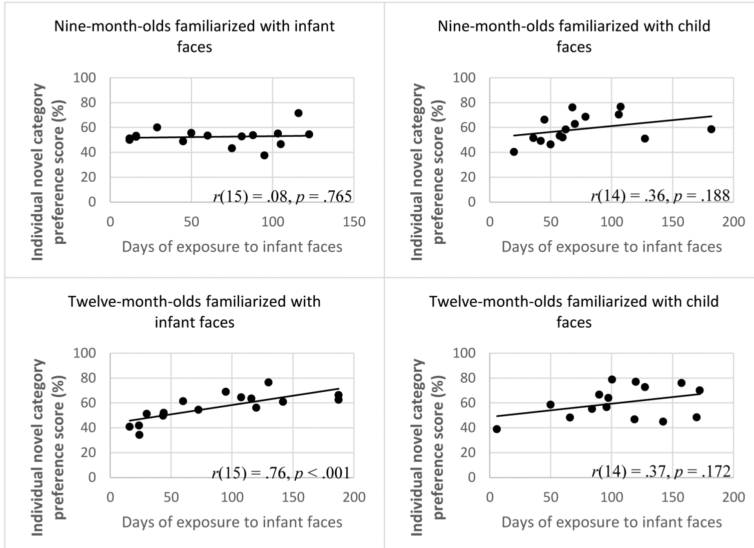

Figure 3 Nine- and 12-month-old correlations between individual novel category preference scores and the number of days of exposure to infant faces for the infant and child face familiarization conditions.

Table 1

Mean fixation times (seconds) during the familiarization trials and mean novel category preference scores (percentages) during the preference test trials of Experiment 1 for 9- and 12-month-old infants.

			Fixation time		Novel category preference			
			Trials 1-2	Trials 3-4				
N	**Age**	**Familiarization Category**	***M* (*SD*)**	***M* (*SD*)**	***M* (*SD*)**	t^{a}	***p***	***d***
14	9	Adult	8.44 (1.16)	8.03 (1.26)	59.59 (9.24)	3.88	.002	1.04
16	9	Infant	9.08 (0.77)	8.37 (1.08)	56.26 (9.24)	2.71	.016	0.68
15	12	Adult	8.65 (1.05)	7.62 (1.35)	58.63 (9.78)	3.42	.004	0.88
15	12	Infant	8.76 (0.83)	7.40 (1.36)	60.34 (11.27)	3.56	.003	0.92

[a] *t* vs.chance.

Table 2

Mean fixation times (seconds) during the familiarization trials and mean novel category preference scores (percentages) during the preference test trials of Experiment 2 for 9- and 12-month-old infants.

			Fixation time		Novel category preference			
			Trials 1-2	Trials 3-4				
N	**Age**	**Familiarization Category**	***M* (*SD*)**	***M* (*SD*)**	***M* (*SD*)**	***t*** [a]	***p***	***d***
15	9	Child	8.55 (0.64)	8.33 (1.22)	58.73 (11.02)	3.07	.008	0.79
16	9	Infant	9.00 (0.67)	8.34 (1.18)	52.46 (7.34)	1.34	.200	0.33
15	12	Child	8.79 (0.85)	8.33 (1.05)	60.11 (13.06)	3.00	.010	0.77
16	12	Infant	8.50 (0.76)	8.00 (0.86)	56.49 (11.24)	2.31	.036	0.58

[a] *t* vs.chance.