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When novelty prevails on familiarity: Visual biases for child versus infant faces in 3.5- to 12-month-olds

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ABSTRACT

The current study examined the influence of everyday perceptual experience with infant and child faces on the shaping of visual biases for faces in 3.5-, 6-, 9-, and 12-month-old infants. In Experiment 1, infants were presented with pairs of photographs of unfamiliar child and infant faces. Four groups with differential experience with infant and child faces were composed from parents' reports of daily exposure with infants and children (no experience, infant face experience, child face experience, and both infant and child face experience) to assess influence of experience on face preferences. Results showed that infants from all age groups displayed a bias for the novel category of faces in relation to their previous exposure to infant and child faces. In Experiment 2, this pattern of visual attention was reversed in infants presented with pictures of personally familiar child faces (i.e., older siblings) compared with unfamiliar infant faces, especially in older infants. These results suggest that allocation of attention for novelty can supersede familiarity biases for faces depending on experience and highlight that multiple factors drive infant visual behavior in responding to the social world.

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Introduction

Perceptual experience with faces during the first year of life is largely redundant, with caregivers and other close relatives comprising most of the social encounters of infants (Jayaraman, Fausey, & Smith, 2015; Sugden & Moulson, 2019). Head-mounted camera studies with infants have revealed that 3-month-olds spend more than half of their daily "face time" exposure seeing their primary and secondary caregivers (i.e., 44% and 17%, respectively; Sugden & Moulson, 2019). This overrepresentation of a few individuals entails that infants are predominantly exposed to some facial characteristics over others, with perceptual experience of faces being biased toward adult-aged, female, and own-race faces (Rennels & Davis, 2008; Sugden, Mohamed-Ali, & Moulson, 2014). It has been pointed out that this asymmetrical experience is correlated with the shaping of visual biases (Quinn et al., 2019). Newborn infants quickly develop a preference for the face of their mother (Bushnell, Sai, & Mullin, 1989; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995; Sai, 2005). Later, at around 3 months of age, this preference extends to unfamiliar female faces (e.g., Fassbender, Teubert, & Lohaus, 2016; Liu et al., 2015; Quinn et al., 2008; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002), adult faces (Heron-Delaney et al., 2017), and own-race faces (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005, 2007; Liu et al., 2015). In sum, preferences for familiar faces extend to unfamiliar adult individuals who share some facial characteristics with the face of the primary caregiver.

To some extent, the visual biases of infants may be related to category learning and face recognition abilities given that early preference for a face category can be a forerunner of early expertise in processing faces belonging to this category. For instance, the initial bias for human faces reported in 3-month-olds (Di Giorgio, Méary, Pascalis, & Simion, 2013) preceded an advantage in processing human faces over other-species faces in 9-month-olds (Pascalis, de Haan, & Nelson, 2002; Scott & Fava, 2013; Simpson, Varga, Frick, & Fragaszy, 2011). A similar developmental course is evident for race and age, with preferences for adult and own-race faces in 3-month-olds (e.g., Heron-Delaney et al., 2017; Kelly et al., 2005) giving way 6 months later to a fine-tuned visual representation of faces favoring the discrimination and recognition of own-race faces over other-race faces (Anzures et al., 2013) and adult faces over infant faces (Kobayashi, Macchi Cassia, Kanazawa, Yamaguchi, & Kakigi, 2018; Macchi Cassia, Bulf, Quadrelli, & Proietti, 2014). Theoretically, the investigation of visual preferences for familiar and unfamiliar face categories in infants thus may provide insights into the developmental course of face recognition and category learning.

The visual biases of infants are furthermore labile and change with age (Quinn et al., 2019). They have been found to switch from an initial bias for familiar face cues to a preference for novelty in infants toward the end of the first year of life, sometimes separated by a transitional period of null preference (for a similar shift in viewing preference in nonhuman infant primates, see also Parr et al., 2016). The exact timing of this developmental shift can vary slightly depending on the facial characteristics at issue and seems to occur earlier for race (i.e., 3–9 months of age; Fassbender, Teubert, & Lohaus, 2016; Liu et al., 2015) than for gender (i.e., 6–12 months of age or later; Juvrud, Rennels, Kayl, Gredebäck, & Herlitz, 2019; Liu et al., 2015; Tham, Bremner, & Hay, 2015). Mechanisms underlying such changes are, however, still unclear. One interpretation of the familiarity-to-novelty shift is that preferences are determined by the quality of the face category representation, which in turn is derived from the cumulative perceptual experience with the category (Liu, Xiao, Quinn, et al., 2015). According to this threshold model, female faces are initially preferred because a robust representation of this category emerges earlier than for male faces, and this preference disappears once infants have accrued enough experience to form a more detailed representation of male faces (Liu, Xiao, Quinn, et al., 2015). Although consistent with the downturn of female face preference reported in 9-month-olds (Liu, Xiao, Quinn, et al., 2015), such an interpretation falls short of explaining a male face preference in older infants (Juvrud et al., 2019) or an own-race to other-race face preference switch. An alternative—but not mutually exclusive—account of the familiarity-to-novelty shift is related to general information processing mechanisms during stimulus learning (e.g., Houston-Price & Nakai, 2004; Hunter & Ames, 1988; Roder, Bushnell, & Sasseville, 2000). An initial bias for familiarity ensures that infants devote sufficient attention toward the stimulus while the representation of that stimulus is beginning to coalesce, and the subsequent bias for novelty occurs once the representation is nearer completion (Roder, Bushnell, & Sasseville, 2000; Rose, Feldman, & Jankowski, 2004; Rose, Gottfried, Melloy-Carminar, & Bridget, 1982). Although initially proposed to account for habituation procedures in laboratory studies, this mechanism could also apply during real-life learning of social categories (e.g., race; Fassbender, Teubert, & Lohaus, 2016; Liu et al., 2015) and could lead infants to switch preference from own-race to other-race faces as their representation of the former is refined with experience.

Considering that previous studies have tended to focus on face preference as derived from the facial characteristics of the primary caregiver, it is entirely unknown whether and how exposure to other relatives such as older siblings affects the development of visual preferences in infants (but see Quinn et al., 2010). To address this question, the current study investigated the influence of exposure to infant and child faces in 3.5-, 6-, 9-, and 12-month-old infants. For obvious ethical and practical reasons, the perceptual experience of each participant cannot be fixed pre-experimentally by the researchers. Hence, sampling infants systematically exposed to either one or the other face category (e.g., male vs. female faces, adult vs. infant faces) may prove to be challenging (see Quinn et al., 2002). Here we tackled this issue through the use of child and infant face categories because natural variation in family composition and caregiving arrangements allows for the selection of infants with various patterns of experience. For instance, infants with older siblings are exposed to child faces because children represent the second age group with whom infants interact most after the caregivers (i.e., 9% of interactions; Rennels and Davis, 2008), whereas other infants with nursery or day-care experience could be exposed to infants or both infant and child face categories. It is worth noting that the amount of experience with either of these face categories is far from reaching the massive exposure involved in visual biases for adult, female, or own-race faces. For example, the preference for adult faces over infant faces (Heron-Delaney et al., 2017) can be related to an exposure of more than 90% for the adult faces (Rennels & Davis, 2008; Sugden, Mohamed-Ali, & Moulson, 2014). Despite a more limited exposure, child or infant faces are, however, likely to influence face processing in infants, as suggested by previous reports on categorization or discrimination abilities (Conte, Proietti, Quadrelli, Turati, & Macchi Cassia, 2019; Damon, Quinn, Heron-Delaney, Lee, & Pascalis, 2016; Proietti, Rigoldi, Croci, & Macchi Cassia, 2018). In these studies, infant face exposure was found to facilitate category formation for infant faces in 12-month-olds (Damon et al., 2016), and child face experience contributed to maintain discrimination abilities of child faces in 9- and 10-month-olds (Conte, Proietti, Quadrelli, Turati, & Macchi Cassia, 2019; Proietti, Rigoldi, Croci, & Macchi Cassia, 2018).

The findings suggest a refined processing of infant and child faces following exposure to these face categories; however, it is unclear whether this experientially based tuning is associated with visual preferences for these faces. According to the pattern of preferences exhibited by infants for age, race, and gender (e.g., Fassbender, Teubert, & Lohaus, 2016; Heron-Delaney et al., 2017; Liu et al., 2015), infants with siblings might present a familiarity bias toward child faces over infant faces, whereas infants exposed to infant faces, but not child faces, might present the reverse preference. Moreover, the pattern of preferences could reverse in older infants, following the familiarity-to-novelty shift reported in previous studies. By contrast, infants exposed to both face categories (or none) may present no preference for child or infant faces regardless of their age. It is also possible that familiarity biases might be limited to caregiver-like face categories in that they would stem from the special relevance of caregivers for infants. Indeed, discriminating the face of the primary caregiver from all other faces is pivotal to forming attachment relationships with caregivers, which is one of the first and most prominent developmental tasks facing infants during the first year of life (Scherf & Scott, 2012).

Other mechanisms may operate in addition to perceptual experience, especially for infant faces. Adults have been found to prefer infant faces over adult faces (Luo et al., 2020; Luo, Li, & Lee, 2011), showing stronger attentional capture when presented with infant faces than when presented with adult faces (Brosch, Sander, & Scherer, 2007; Proverbio, De Gabriele, Manfredi, & Adorni, 2011) and showing greater responsivity to infantile cues (Golle, Lisibach, Mast, & Lobmaier, 2013; Hildebrandt & Fitzgerald, 1979; Little, 2012; Sprengelmeyer et al., 2009). This “baby schema” effect (Lorenz, 1943) is construed to be related to the particular infant facial characteristics (i.e., protruding forehead, round face, big eyes below the midline of the face, and small nose or mouth) and is believed to trigger caretaking behavior and decreased aggression, as adaptive responses (for a review, see Kringelbach, Stark, Alexander, Bornstein, & Stein, 2016). For this reason, it has been proposed that infants could be biased toward infant faces (McCall & Kennedy, 1980; Sanefuji, Ohgami, & Hashiya, 2005, 2006). So far, however, when infant faces have been paired with adult faces, studies either failed to find significant preference (Lewis & Brooks, 1975, Sanefuji et al., 2005) or even reported a preference for adult faces (Heron-Delaney et al., 2017). Because the overwhelming familiarity of adult faces might have prevailed on a potentially subtler sensibility to the baby schema (Sanefuji et al., 2005), the infant/child face comparison may prove to be better suited to assess infant preference for infant faces than the infant/adult face contrast (Lewis & Brooks, 1975; Sanefuji et al., 2005). Furthermore, findings that 11.5-month-olds exhibit a preference for individuals sharing similarities with themselves in a "like me/not like me" comparison process (Mahajan & Wynn, 2012; for related discussions on the developmental origin of a "like me" representation, see also Meltzoff, 2005, 2007) also support the idea that infants might present a bias for infant faces over child faces.

To clarify these issues, we examined the visual preferences of 3.5-, 6-, 9-, and 12-month-olds for unfamiliar infant (6-month-old) and child (5- to 7-year-old) faces in relation to the prior perceptual experience of infants with these face categories. From the literature, several hypotheses can be offered. First, infants could display a preference for familiar face categories (either child or infant faces, depending on everyday experience), as reported for gender, race, or age face categories. Conversely, infants could show a general preference for novel face categories. A third possibility could be that infant and child face preferences follow a similar developmental course to that reported for female or own-race face preferences (e.g., Fassbender, Teubert, & Lohaus, 2016; Liu et al., 2015), exhibiting a familiarity-to-novelty shift where younger infants show a familiarity bias and older infants show a novelty bias. Finally, a fourth possibility could be that infants are sensitive to the baby schema effect and present a preference for infant faces, superseding or interacting with other biases stemming from their everyday experience. We sampled an age range covering the first 12 months of life to assess developmental change, if any.

Experiment 1

Method

Participants

A total of 200 infants were included in the final statistical analysis. Participants were 47 full-term 3.5-month-olds (26 girls; age range = 101–142 days), 56 6-month-olds (23 girls; age range = 179–200 days), 50 9-month-olds (27 girls; age range = 266–294 days), and 47 12-month-olds (19 girls; age range = 365–388 days). Data were collected in Grenoble, France. Infants were recruited using a local database and through contact at the regional maternity ward. Infants were 89% Caucasian, 3.5% North African, 1.5% Black (West African), 3.5% Caucasian and North African, 1.5% Black and Caucasian, and 1% Asian and Caucasian. An additional 62 infants participated in the experiment but were eliminated from the analysis due to technical problems or mother's interference during recording (n = 1 for 3-month-olds, n = 4 for 6-month-olds, n = 1 for 9-month-olds, and n = 1 for 12-month-olds), changing state during the test (e.g., infant became too tired and/or started to sleep or cry; n = 1 for 6-month-olds and n = 1 for 9-month-olds), strong side bias (i.e., infant looked in one direction for more than 95% of the looking time; n = 19 for 3-month-olds, n = 3 for 6-month-olds, and n = 2 for 9-month-olds), insufficient looking time toward the stimuli (i.e., infant looked less than 50% of time, i.e., 5 s; n = 1 for 3-month-olds, n = 1 for 6-month-olds, and n = 2 for 9-month-olds), or failure to compare both stimuli (n = 18 for 3-month-olds, n = 5 for 6-month-olds, n = 1 for 9-month-olds, and n = 1 for 12-month-olds). No infants had a twin. Experience groups were composed as follows:

Participants with no experience with either infant or child faces (NE group): The NE group comprised 50 infants who had no siblings and did not attend a nursery. If looked after by a childminder, they were not with other infants or children.

Participants with infant face experience only (IE group): The IE group comprised 50 infants who had experience with infants younger than 36 months either at a nursery or via their childminder. In France, where the study was conducted, infants can attend a nursery from 3 to 36 months of age.

Participants with child face experience only (CE group): The CE group comprised 50 infants who had at least one sibling older than 36 months (mean age = 4.8 years, *SD* = 2.2, age range = 3–11) or were cared for by a childminder with at least one child older than 36 months. These infants did not go to a nursery and were not exposed daily to infant faces.

Participants with both infant and child face experience (ICE group): The ICE group comprised 50 infants who attended a nursery and had at least one sibling older than 36 months (mean age = 4 .8 years, *SD* = 2.2, age range = 3–11) or were cared for by a childminder with at least one infant from 3 to 36 months of age and one child older than 36 months.

Stimuli

The stimuli presented to infants were 16 color photographs of Caucasian child and infant faces collected in France and the UK. Child faces were 5–7 years of age, and infant faces were 6 months of age. Faces were paired to match for eye and hair color. All faces were presented against a white background (see Fig. 1). Faces were presented in frontal orientation with neutral or slightly positive expressions. Stimulus size and brightness were kept uniform using Adobe Photoshop. When projected onto the screen, each picture was 17.5 cm high and 14 cm wide and separated by a 22-cm gap (subtending ~ $28^\circ \times 23^\circ$ visual angle at a 60-cm viewing distance). There were eight different face sets: four with male faces and four with female faces. Each set contained two pairs of child/infant faces. Infant and child faces were rated on attractiveness by 20 undergraduate students who were given course credit as compensation. Faces were rated on a 9-point Likert scale (1 = *not attractive at all,* 5 = *neutral,* 9 = *very attractive*). There was no significant differences between infant and child faces, $t(19) = -1.39$, $p = .179$, Hedges' $g = 0.30$, 95% confidence interval (CI) = [−0.89, 0.18] ($M_{\text{infant faces}} = 4.84$, $SD = 1.47$; $M_{\text{child faces}} = 5.19$, $SD = 0.89$). Examples of the stimuli can be found in Fig. 1.

Procedure

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. Each participant saw two child/infant pairs of photographs. Each pair that was presented contained a different child and infant face for each trial. Left–right positioning of the photographs was counterbalanced across infants on the first trial and then reversed on the second trial. Gender was counterbalanced between infants so that each infant saw only male or female faces throughout the trials. Before each trial, an attention getter (i.e., a soundless, moving abstract geometric form located at the middle of the screen) was presented until the infant looked at the middle of the screen. Image presentation was controlled using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA, USA). The trial started when the infant looked at one of the two stimuli and ended after 10 s had elapsed. Our cross-sectional design entailed selecting a duration that should be neither too long for older infants nor too short for younger infants. This parameter was determined based on previous studies either examining face preference using a cross-sectional design with the same age range (i.e., 3- to 12-month-olds; Dupierrix et al., 2014) or assessing face preference in 3-month-olds only (Quinn et al., 2002, 2008). The observer was positioned behind the screen, recording the looking times of the infants with a camera situated just above the stimulus display, surrounded by a black background. The film was subsequently digitized to be ana-

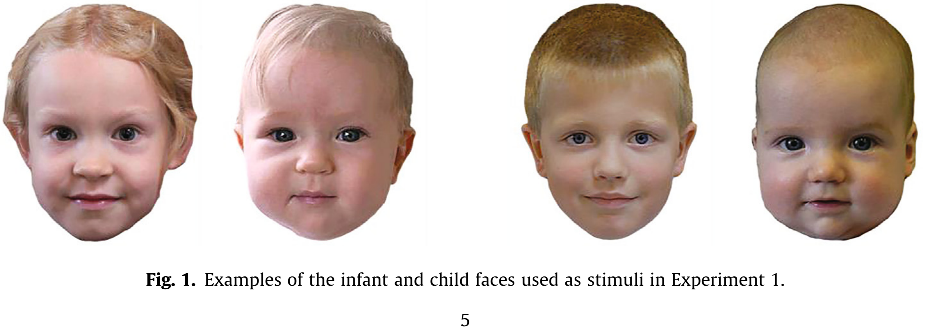

Fig. 1. Examples of the infant and child faces used as stimuli in Experiment 1.

lyzed frame by frame on a computer using homemade specialized software. An independent observer recoded 25% of the data for reliability. Both observers were blind to the side of presentation of the pictures and to the experience group of the infants. The average level of inter-observer agreement was high (Pearson's r = .96).

Results and discussion

Analyses were performed on the percentage of time spent looking at the infant faces for each participant. These scores corresponded to the summed looking time to infant faces divided by the summed looking time to both child and infant faces, which was then converted to a percentage score by multiplying by 100. Percentage scores higher than 50% mean that infants looked longer toward the infant faces than toward the child faces. All analyses were performed with an alpha threshold defined at α = .05. Infants exposed to neither infant nor child faces (i.e., the NE group) can be seen as a control group; hence, preferences for infant or child faces in all three experience groups (i.e., IE, CE, and ICE) were compared with this baseline group using Dunnett's multiple comparisons post hoc test. Although these comparisons could be seen as a set of planned contrasts and analyzed as such, they are non-orthogonal. Therefore, the Dunnett's test is preferable in terms of balance between statistical power and convenience in controlling the experiment-wise Type I error rate (Ruxton & Beauchamp, 2008). Effect sizes are Hedges' g and partial η^2 (η^2_p). Data showed no departure from normality (Kolmogorov–Smirnov test, p > .20). We supplemented frequentist statistical analysis with Bayes factors, such that both accepting and rejecting the null hypotheses are possible (see, e.g., Dienes, 2014, advocating for this approach).

The percentage of looking time at infant faces was entered into a general linear model (GLM) with experience with infant and child faces (NE, IE, CE, or ICE group) as a categorical predictor and participant age (in days) as a continuous predictor. The analysis yielded a main effect of experience with infant and child faces, $F(3, 192)$ = 11.61, p < .001, η^2_p = .15. Dunnett-corrected (two-sided) groupwise comparisons further indicated that the IE and CE groups differed from the NE group, displaying either shorter looking time (i.e., IE group vs. NE group, p = .050) or longer looking time (i.e., CE group vs. NE group, p = .003) toward infant faces than NE infants (see Fig. 2). By contrast, infants exposed to both face categories showed looking time similar to that observed in the NE group. Strikingly, there was no effect of participant age or any interaction (both Fs < 1), suggesting that infants showed no shift in preference with age. Although unexpected, the results indicate that infants showed a preference for the novel face category, which is especially evident in infants exposed to child faces only.

To further ascertain whether the comparison of IE, CE, and ICE groups with the NE group provided evidence for either the alternative hypothesis (a difference with the NE group) or for the null hypothesis (an equivalence with the NE group), we used Jamovi software Version 1.6.3 (https://www.jamovi.org) to calculate the Bayes factors for each comparison with the NE group using the default priors. Bayes factors over 3 or under 1/3 represent substantial evidence for the alternative or null hypothesis, respectively, with values close to 1 representing weak or anecdotal evidence (Dienes, 2014). We found strong evidence that the CE group differed from the NE group (BF_{10} = 25.797), indicating that the data are more than 25 times more likely to be observed under the hypothesis than under the null, and found anecdotal evidence that the IE group differed from the NE group (BF_{10} = 1.545). Regarding the ICE versus NE comparison, the Bayes factor (BF_{10} = 0.224) suggests that our data are more likely to be observed under the null, indicating more than four times the evidence for the null hypothesis (no difference between the two groups).

In addition, we examined whether each group's face preference score was different from chance (i.e., 50%), which would indicate a preference for infant or child faces, and tested the groups by performing one-sample Student t tests (see Table 1). To account for multiple comparisons leading to possible familywise Type I errors, we divided α = .05 by 4, setting α = .0125. The one-sample t tests (α = .0125) comparing the mean face preference score from each group with chance revealed that the CE group had a significant preference for infant faces (M_{CE} = 58.70%, SD = 7.45), $t(49)$ = 8.26, p < .001, Hedges' g = 1.15, 95% CI = [6.58, 10.81], with 88% of CE infants looking toward infant faces more than toward child faces. Each of the other three groups failed to show a significant preference for child or infant faces (see Table 1).

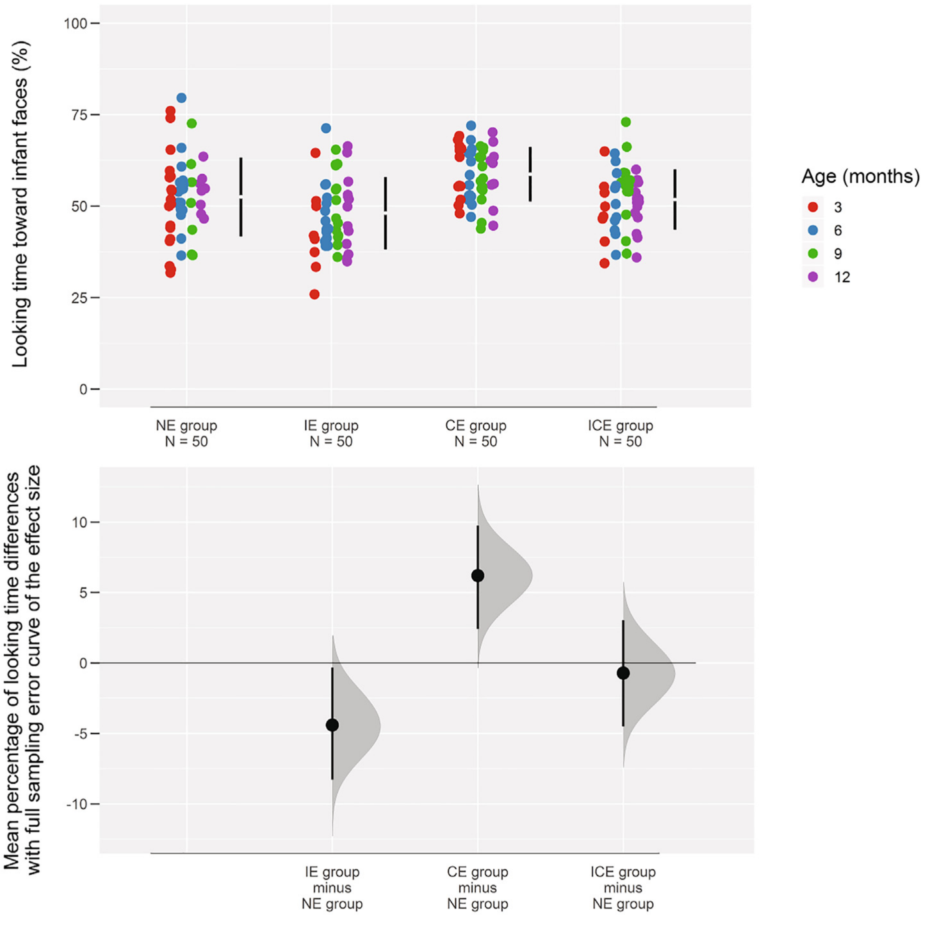

Fig. 2. Top panel: Swarm plots of the distribution of looking time percentage toward infant faces depending on previous experience with infant and child faces. Vertical black bars indicate the standard deviation around the group mean (shown as a gap). Bottom panel: Estimation plots (Ho, Tumkaya, Aryal, Choi, & Claridge-Chang, 2019) showing the mean difference in percentage of looking time toward infant faces of the IE group (infant face experience only), CE group (child face experience only), and ICE group (both infant and child face experience) compared with the NE group (no experience with either infant or child faces) (with effect sizes represented by black circles), the distribution of these effect sizes obtained through nonparametric bootstrap resampling (5000 samples; shaded areas), and their 95% confidence intervals (black bars).

Table 1
Mean percentages of looking time (and standard deviations) toward infant faces in NE, IE, CE, and ICE groups.

Experience group	*n*	*M* (*SD*)	*t*	*p*	Hedges' *g*	95% *CI*
NE	50	52.50 (10.78)	1.64	.108	0.23	[−0.57, 5.56]
IE	50	48.09 (9.90)	−1.37	.178	0.19	[−4.72, 0.90]
CE	50	58.70 (7.45)	8.26	<.001	1.15	[6.58, 10.81]
ICE	50	51.78 (8.27)	1.52	.135	0.21	[−0.57, 4.13]

Note. NE, participants with no experience with either infant or child faces; IE, participants with infant face experience only; CE, participants with child face experience only; ICE, participants with both infant and child face experience; *CI*, confidence interval.

Surprisingly, the novelty effect seems limited to infants exposed to child faces given that IE infants did not present a significant bias toward child faces. It should be noted, however, that the preference score from the NE group might be a better estimate of infants' bias toward child or infant faces than the chance level of 50% (Eimas & Quinn, 1994). In particular, the preference score of the NE infants provides an empirical estimate of the bias for infant faces (i.e., the baby schema effect) without the influence of experience. When this baseline group is taken as the natural preference against which the preference scores of the other groups are compared, both the IE and CE groups are significantly different from the NE group, $t(49) = -3.15$, $p = .003$, Hedges' $g = 0.44$, 95% CI [−7.22, −1.60], and $t(49) = 5.88$, $p < .001$, Hedges' $g = 0.82$, 95% CI [4.08, 8.31], respectively, whereas the ICE group is not, $t(49) = -0.62$, $p = .539$, Hedges' $g = 0.09$, 95% CI [−3.07, 1.63]. In addition, 76% of the CE infants showed preferences above the mean preference of the NE group, 72% of the IE infants showed preferences below the mean preference of the NE group, and 50% of the ICE infants showed preferences above the mean preference of the NE group.

Both the IE and CE groups displayed preferences for the categorically novel faces (i.e., the infant faces) regardless of age. By contrast, infants exposed to both categories of faces showed no preference. Such an outcome stands in contrast to findings reporting consistent familiarity preferences when it comes to social choices (e.g., female faces: Quinn et al., 2002; own-race faces: Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005; adult faces: Heron-Delaney et al., 2017). Although the current use of child and infant face categories allowed for sampling infants differentially exposed to one or the other face category (or both face categories), a drawback is that the amount, and perhaps more crucially the quality, of experience with infants or children might not be equivalent to their experience with adults (Quinn & Eimas, 1998). This is especially the case when considering the caregivers, who alone represent more than 50% of all face exposure (Sugden & Moulson, 2019) and likely have a special affective status for the infants. Hence, these individuals might carry more weight in the face representations of infants than other faces, leading to the development of a preference for the face category to which they pertain (for a similar argument for the development of gender preferences, see Quinn et al., 2002). By contrast, infants had a much weaker exposure to the categories of infant or child faces (e.g., exposure to sibling faces represents at best 9% of interactions; Rennels and Davis, 2008). Although speculative, a possibility is that the amount of real-world perceptual experience accrued by infants with older siblings (or infants) is insufficient to create a familiarity bias that extends to the whole child (or infant) face category.

Contrary to our hypothesis, findings from Experiment 1 indicated that overall infants displayed visual biases for unfamiliar face categories. The rationale for Experiment 1 was built on the idea that preference for frequently encountered familiar faces may extend to the whole category to which they pertain provided that enough exposure or expertise is accumulated with these individuals as reported for the face of the primary caregiver. The extension of preference from an individual to a category entails that some face characteristics of this individual (e.g., gender, race, age) are detected in unfamiliar faces, hence triggering the category preference. However, an unknown issue is whether familiar relatives other than the primary caregiver may also drive the visual interest of infants when compared with unfamiliar individuals. Because experience accumulated with sibling faces is far from reaching that of adult faces, the effect on the visual preferences of infants may be more subtle, although analogous. That is, infants may exhibit a visual bias for the actual child faces they encounter in their home environment while showing no generalization to other members of the same age face category. To test this possibility, in Experiment 2 we probed the visual preferences of 3.5- to 12-month-old infants for infant and child faces presented either with unfamiliar infant and child faces or with an unfamiliar infant face paired with their sibling face.

Experiment 2

In Experiment 2, we sought to directly examine the effect of personal familiarity while controlling for categorical experience. The "Familiar" group consisted of infants presented with the face of their older sibling paired with an unfamiliar infant face. As in Experiment 1, infants from the Familiar group were further classified into an experience group (i.e., CE or ICE) depending on their everyday experience with faces. Each infant in the Familiar group was then systematically matched with another infant based on both age (3.5, 6, 9, or 12 months) and categorical face experience (CE or ICE). These matching infants formed the "Unfamiliar" group and were presented with the same pairs of stimuli presented to infants from the Familiar group. For the Unfamiliar group infants, however, both child and infant faces depicted unfamiliar individuals. Therefore, the Unfamiliar group was similar to the CE and ICE groups of Experiment 1. None of the infants included in Experiment 2 had participated in Experiment 1.

Method

Participants

A total of 70 infants were included in the final statistical analysis. Participants were 16 3.5-month-olds (9 girls; age range = 105–123 days), 12 6-month-olds (3 girls; age range = 183–199 days), 20 9-month-olds (10 girls; age range = 271–291 days), and 22 12-month-olds (10 girls; age range = 366–388 days). Data were collected in Grenoble, France. Infants were recruited using our database and through contact at the local maternity ward. All infants were Caucasian (to match with our infant face database). An additional 16 infants participated in the experiment but were eliminated from the analysis due to technical problems ($n = 1$ for 3-month-olds and $n = 2$ for 12-month-olds), strong side bias (i.e., infant looked in one direction for more than 95% of the looking time; $n = 1$ for 3-month-olds and $n = 1$ for 6-month-olds), or failure to compare both stimuli ($n = 7$ for 3-month-olds, $n = 1$ for 6-month-olds, $n = 1$ for 9-month-olds, and $n = 2$ for 12-month-olds). One 12-month-old from the Familiar group was identified as an outlier (based on absolute median deviation; see Leys, Ley, Klein, Bernard, & Licata, 2013) and was removed from the analysis (along with her matched counterpart in the Unfamiliar group).

A total of 35 infants were included in the Familiar group and were presented with pictures of one of their older siblings paired with an unfamiliar infant. The other 35 infants were included in the Unfamiliar group and were matched on age and exposure to infant and child faces with infants from the Familiar group. Each infant from the Unfamiliar group was presented with the same pairs as a matched counterpart from the Familiar group. Infant experience with child and infant faces was assessed in the same way as in Experiment 1. In total, there were 44 infants exposed to both infant and child faces (Familiar group: $n = 22$; Unfamiliar group: $n = 22$) and 26 infants exposed to child faces only (Familiar group: $n = 13$; Unfamiliar group: $n = 13$).

Stimuli

A total of 35 pairs of Caucasian child faces (age range = 3–11 years) and infant faces (6 months of age) were created based on pictures of older siblings of infants included in our sample and unfamiliar infants from our local face database. The experimenter took pictures of siblings of the infants at the homes of the participants 1 week before testing. Faces were paired to match eye and hair color. All faces were presented against a white background. Faces were presented in frontal orientation with neutral or slightly positive expressions. Stimulus size and brightness were kept uniform by using Adobe Photoshop. When projected onto the screen, each picture was 17.5 cm high and 14 cm wide and separated by a 22-cm gap (subtending $\sim 28^\circ \times 23^\circ$ of visual angle at a 60-cm viewing distance).

Procedure

The procedure was similar to that of Experiment 1 except that the parents were blindfolded to prevent them from interfering with the looking behavior of their infants (even involuntarily) by recognizing their children when presented on the screen, especially because they might have expectations about the sibling recognition abilities of their infants. Left–right positioning of the photographs was counterbalanced across infants on the first trial and then reversed on the second trial. Because we used the actual faces of the siblings of the participants, the first and second trials necessarily depicted the same individual; hence, the same unfamiliar infant was also used in both trials. An independent observer recoded 25% of the data for reliability. Both observers were blind to the side of presentation of the pictures and to the experience group of the infants. The average level of inter-observer agreement was high (Pearson's $r = .98$).

Results and discussion

Analyses were performed on the percentages of time spent looking at the infant faces for each participant. These scores corresponded to the summed looking time to infant faces divided by the summed looking time to both child and infant faces, which was then converted to a percentage score by multiplying by 100. Effect sizes are Hedges' *g* and η_p^2. Data showed no departure from normality (Kolmogorov–Smirnov test, $p > .42$). Bayes factors were calculated to complement *t* tests.

The percentage of looking time at infant faces was entered into a GLM with experience (CE or ICE group) and familiarity (familiar or unfamiliar child faces) as categorical predictors and participant age (in days) as a continuous predictor. The analysis revealed a significant main effect of participant age, $F(1, 62) = 4.37$, $p = .041$, $\eta_p^2 = .07$, indicating that looking time toward infant faces decreased as infants grew older. We also found a significant effect of familiarity, $F(1, 62) = 7.81$, $p = .007$, $\eta_p^2 = .11$, showing that infants presented with pictures of their older siblings paired with unfamiliar infant faces looked more toward the familiar faces than infants from the Unfamiliar group ($M_{Familiar} = 49.80\%$, $SD = 7.54$ and $M_{Unfamiliar} = 54.79\%$, $SD = 7.07$, respectively) (see Fig. 3) and suggesting the development of visual biases for the face of the sibling, possibly indicating a form of identity recognition. There was no effect of experience ($F < 1$) or any other interaction [Experience * Participant Age, $F < 1$; Familiarity * Experience, $F(1, 62) = 2.34$, $p = .131$, $\eta_p^2 = .04$; Familiarity * Experience * Participant Age, $F(1, 62) = 2.70$, $p = .106$, $\eta_p^2 = .04$], although the Familiarity * Participant Age interaction approached significance, $F(1, 62) = 3.37$, $p = .071$, $\eta_p^2 = .05$.

CE and ICE infants from the Unfamiliar group in Experiment 2 can be considered as forming a replication of the CE and ICE groups of Experiment 1, but with other infants and different stimuli. Accordingly, the results of Experiment 2 indicated that infants from the Unfamiliar group showed looking time similar to infants from Experiment 1 relative to their facial experience group (i.e., $M_{Unfamiliar\ CE} = 57.43\%$, $SD = 4.53$ and $M_{UnfamiliarI\ CE} = 53.23\%$, $SD = 7.89$, respectively), both *ps* > .49. In addition, Bayes factors for these comparisons ($BF_{10} = 0.349$ and $BF_{10} = 0.320$, respectively) provide moderate evidence that

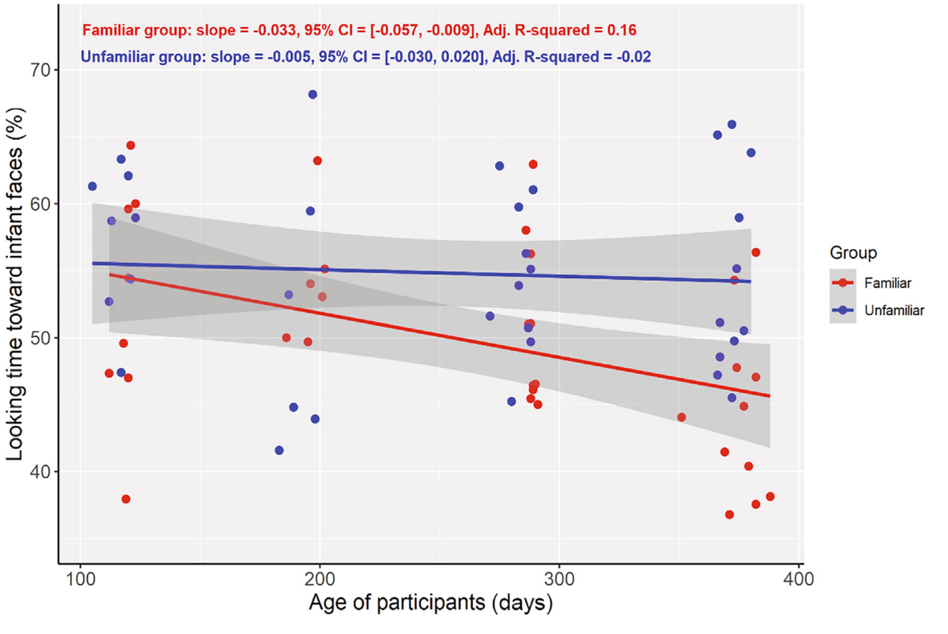

Fig. 3. Scatter plots illustrating the relationship observed across Familiar and Unfamiliar groups between the percentage of looking time toward infant faces and the age of the participants (in days), with regression lines and 95% confidence bands (shaded areas). The significant slope value of the Familiar group indicates that the percentage of looking time toward infant faces decreases 0.033% per day. CI, confidence interval; Adj. R-squared, adjusted R^2.

the groups were equivalent between experiments and indicate that these data are 2.7 and 3.1 times more likely to be observed under the null hypothesis. By contrast, infants from the Familiar group with child experience presented a significantly shorter looking time percentage toward infant faces than the CE infants from Experiment 1 ($M_{\text{Familiar CE}}$ = 49.76%, *SD* = 8.51 and M_{CE} = 58.70%, *SD* = 7.45, respectively), $t(61) = 3.74$, $p < .001$, Hedges' $g = 1.15$, 95% *CI* [−13.71, −4.17]. The Bayes factor indicated very strong evidence (BF_{10} = 63.85) that these two groups are different. Looking time toward infant faces from the Familiar group with both infant and child experience, however, was not significantly different from the ICE infants from Experiment 1 ($M_{\text{Familiar ICE}}$ = 49.83%, *SD* = 7.11 and $M_{\text{Experiment1 ICE}}$ = 51.78%, *SD* = 8.27%, respectively), $t(70) = 0.96$, $p = .340$, Hedges' $g = 0.24$, 95% *CI* [−6.00, 2.10], BF_{10} = 0.384.

Exploratory analysis

To further explore the familiarity effect, infants were parsed by age group (3.5-, 6-, 9-, and 12-month-olds) and percentage preferences were compared between the Familiar and Unfamiliar groups (see Fig. 4). Only 12-month-olds from the Familiar group displayed a reliable preference for the sibling faces compared with matched infants from the Unfamiliar group ($M_{\text{Familiar12}}$ = 44.43%, *SD* = 6.54 and $M_{\text{Unfamiliar12}}$ = 54.70%, *SD* = 7.54, respectively), $t(10) = -3.15$, $p = .010$, Hedges' $g = 0.88$, 95% *CI* [−17.52, −3.00]), whereas all other age groups failed to show significant differences

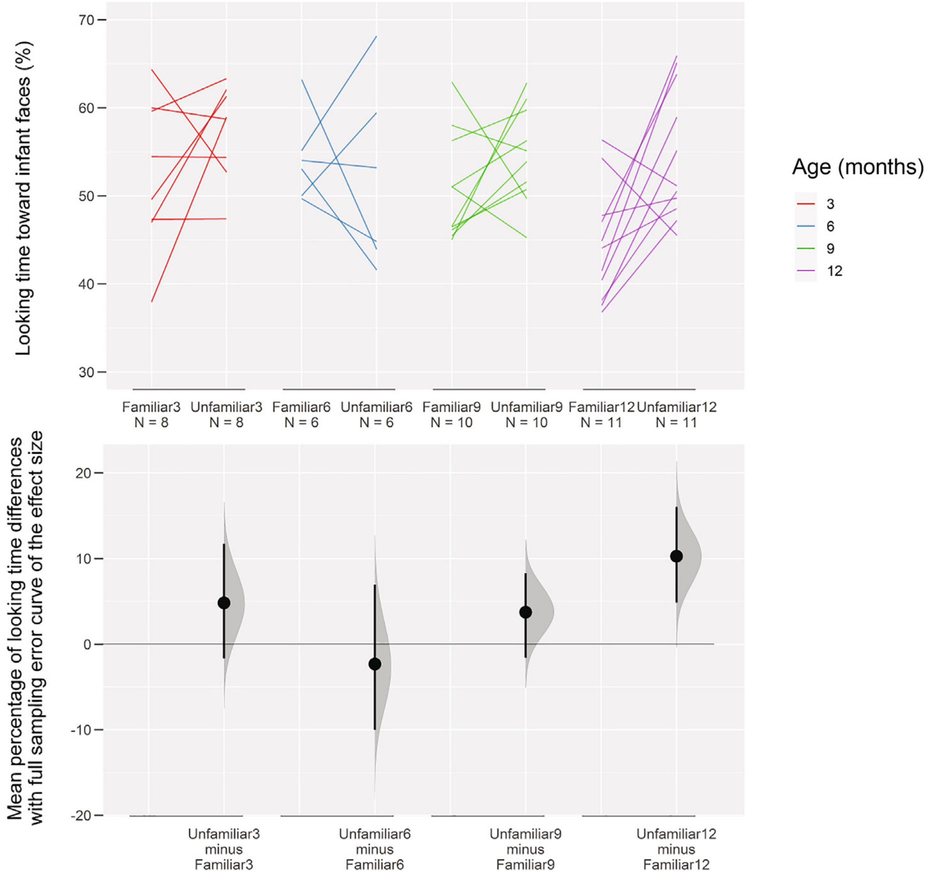

Fig. 4. Top panel: Slope graph depicting the matched pairs of percentage of looking time toward infant faces depending on age group. Bottom panel: Estimation plots showing the paired mean difference in percentage of looking time toward infant faces of 3.5-, 6-, 9-, and 12-month-olds (i.e., effect sizes; black circles), the distribution of these effect sizes obtained through nonparametric bootstrap resampling (5000 samples; shaded areas), and their 95% confidence intervals (black bars).

(all *ps* > .23) (see Table 2). Although the interaction between age and familiarity was not significant, probably due to insufficient statistical power, the current pattern of results appears to be mostly driven by the older age group (i.e., the 12-month-olds). Differences in percentage of looking time between the Familiar and Unfamiliar groups were maximal in infants from this age group, suggesting that a bias for the face of older siblings may develop by the end of the first year of life.

General discussion

By relying on natural variation in exposure to infant and child faces in infants during the first year after birth, we examined the influence of everyday experience in shaping visual biases for these categories of faces. Contrary to expectations, we observed a general trend to look longer toward the most novel category; infants exposed to child faces showed clear and strong attentional biases for infant faces, whereas infants exposed to infant faces showed shorter looking time toward this category. In addition, infants exposed to both infant and child faces showed visual preference behavior similar to that of infants without exposure to these categories.

A comprehensive social cognition framework must account for the development of biases toward familiar and novel face categories, and the current results complement the existing developmental literature by examining how experience shapes visual biases for faces differing by age. As noted previously, some theories have reported that face biases originate from the social environment (Quinn et al., 2019), following asymmetric exposure to some face categories over others, which results in familiarity-based biases for adult faces (Heron-Delaney et al., 2017), female faces (e.g., Liu et al., 2015; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002), and own-race faces (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005, 2007). These visual biases for familiar categories eventually shift to novelty preferences in older infants (e.g., Fassbender, Teubert, & Lohaus, 2016; Juvrud, Rennels, Kayl, Gredebäck, & Herlitz, 2019; Liu et al., 2015). Yet, our results suggest that development of age-based visual attention is not entirely compatible with such theories. The pattern of attention to faces we found indicates a bias for novelty that is present even in younger infants (i.e., 3.5-month-olds), one that is maintained until the end of the first year of life.

One reason for the difference may lie in the statistics of the visual experience that infants have with siblings (i.e., 9% of interactions; Rennels and Davis, 2008), which are weaker than the statistics reported for adult and female faces (i.e., ~ 70% and 80% of interactions, respectively; Rennels and Davis, 2008). Although this perceptual experience has been found to promote learning of the experienced face categories (e.g., Damon, Quinn, Heron-Delaney, Lee, & Pascalis, 2016; Proietti, Rigoldi, Croci, & Macchi Cassia, 2018), it is not accompanied by a visual bias for the familiar category. Thus, without operation of this latter bias, other general tendencies in viewing behavior might prevail, such as allocation of attention to novelty (Fantz, 1964), and guide infants to explore the categorically more novel faces. This overall pattern of results is consistent with an account in which a representation of infant or child faces is developing with face experience either through nursery or with older siblings, resulting in more efficient processing for these categories (Conte, Proietti, Quadrelli, Turati, & Macchi Cassia, 2019; Damon, Quinn, Heron-Delaney, Lee, & Pascalis, 2016; Proietti, Rigoldi, Croci, & Macchi Cassia, 2018). The difference in the robustness of the representations based on differential experience might

Table 2
Mean percentages of looking time (and standard deviations) toward infant faces in Familiar and Unfamiliar groups depending on age of infants.

Age (months)	*n*	$M_{Familiar}$ (*SD*)	$M_{Unfamiliar}$ (*SD*)	*t*	*p*	Hedges' *g*	95% *CI*
3	8	52.54 (8.69)	57.35 (5.45)	−1.30	.236	0.41	[−13.60, 3.96]
6	6	54.19 (4.93)	51.86 (10.42)	0.46	.662	0.16	[−10.56, 15.22]
9	10	50.88 (6.24)	54.61 (5.53)	−1.28	.233	0.37	[−10.33, 2.87]
12	11	44.43 (6.54)	54.70 (7.54)	−3.15	.010	0.88	[−17.52, −3.00]
All	35	49.80 (7.53)	54.79 (7.07)	−2.69	.011	0.44	[−1.22, −8.76]

Note. CI, confidence interval.

have driven infants to allocate more visual attention toward unfamiliar face categories for which they have poorer processing efficiency (Liu, Xiao, Xiao, et al., 2015).

The current findings highlight that multiple factors determine the visual behavior of infants in responding to the social world and qualify the view that social preferences manifest mainly by visual biases for familiar stimuli. Although novelty preferences are typically found in studies with non-face objects (e.g., Houston-Price & Nakai, 2004), developmental profiles of visual preference for own-race versus other-race faces (Liu, Xiao, Xiao, et al., 2015) or female versus male faces (Juvrud, Rennels, Kayl, Gredebäck, & Herlitz, 2019; Liu et al., 2015) indicate that infants may display novelty preferences toward other-race and male faces in older infants. These findings, along with the current pattern of outcomes, lend support to the suggestion that some aspects of infant face processing might not be face specific but rather reflect perceptual operations of a more general processing system that can apply to both face and non-face objects (Quinn, Tanaka, Lee, Pascalis, & Slater, 2013).

Of additional theoretical significance is that personal familiarity influences the visual behavior of infants and that this influence increases as infants grow older. Furthermore, visual biases for the sibling's face seem to emerge at around 12 months of age, although this conclusion should remain provisional due to the exploratory nature of the statistical analyses. More generally, infants presented with personally familiar faces showed differential looking behavior compared with infants presented with categorically, but not personally, familiar faces. Although actual determinants of visual attention are difficult to pinpoint with certainty from looking time measures in preverbal infants (Aslin, 2007), these findings likely reflect the perception of a personally familiar face. To our knowledge, this is the first study documenting the development of visual recognition of relatives beyond the primary caregiver in infants during their first year of life. Results of Experiment 1 indicate that 3.5 months of experience with siblings is sufficient to affect visual preferences of infants, likely shaping a rudimentary category representation of child faces. However, in line with discrimination studies (e.g., Proietti et al., 2018), refined identity-based processing of child faces may require accumulating more experience, as attested by the later-developing familiarity bias for sibling faces in Experiment 2. Such an interpretation would also be consistent with findings that robust face representations of child and infant faces are only emerging toward the end of the first year of life (Damon et al., 2016).

Of note is that the incident knowledge provided by the learning of an older sibling's face (i.e., the child age category) translated into a novelty preference for infant faces when infants were presented with unfamiliar infant and child identities. Preference for familiar face categories (e.g., Heron-Delaney et al., 2017; Kelly et al., 2005; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002), at least during the first 6 months of life, likely derives from predominant exposure to the primary caregiver (i.e., ~44% of all face exposure; Sugden & Moulson, 2019) along with the overall responsiveness displayed by this individual (Quinn et al., 2019). In comparison, experience with older siblings (or with infants through day care) entails quantitatively—and probably qualitatively—different interactions. This experience would appear to have been sufficient to create a bias toward the face of a personally familiar individual, but not enough to extend this bias to the category embedding the face, further suggesting that a large amount of experience seems to be necessary before visual biases generalize from a face identity to the whole-face category. Intriguingly, although older infants necessarily have more experience with the category of faces they encounter in everyday life than younger infants, there was no age-related gradation in the novelty preference. A possibility is that a quantitative measure of the exposure to infant or child faces would have allowed a finer examination of the presence of a correlation between the exposure and the strength of the novelty preference for infant (or child) faces.

An issue raised by the current results is whether familiarity and novelty preference underlie liking or interest in infants given that these mechanisms are notoriously difficult to disentangle from mere looking times. In adults, consistent with Bowlby (1988), familiarity preference has been linked to liking, whereas novelty seeking has been associated more with interest (Sung, Vanman, & Hartley, 2019). Indirect evidence suggests that this distinction may also apply in infants given that they have been found to look longer toward familiar stimuli imbued with emotionally positive valence compared with novel neutral stimuli (Brown, Robinson, Herbert, & Pascalis, 2006; Nachman, Stern, & Best, 1986; Najm-Briscoe, Thomas, & Overton, 2000; but see Xiao et al., 2018). In other words, familiar stimuli with conditioned value (e.g., the caregiver) may override an otherwise typical novelty preference. In accord with this suggestion, 3-month-old infants of depressed mothers fail to show the typical preference for the face of their mother (Jones, Slade, Pascalis, & Herbert, 2013) or even show novelty preference for the face and voice of a stranger over those of their mother (Taylor, Slade, & Herbert, 2014), presumably because depressed mothers may engage in less rewarding social interactions than nondepressed mothers. Although tentative, an interpretation of the current findings would be that sibling faces elicit familiarity preference over novel unfamiliar faces due to accumulated reinforcing interactions even though the amount of experience with siblings is not sufficient to induce a bias for the whole child face category.

The current findings also have theoretical implications regarding sensitivity to the baby schema. Infants with no experience with infant or child faces presented only a weak bias for infant faces, which turned out to be nonsignificant. Consistent with earlier studies (Heron-Delaney et al., 2017; Sanefuji et al., 2005), the current study failed to provide clear support for sensitivity to the baby schema in infants, suggesting that this bias may emerge later in development. However, the onset of this sensitivity is unclear, presumably emerging during childhood, with 3-year-olds having shown responsivity to infantile cues (Borgi, Cogliati-Dezza, Brelsford, Meints, & Cirulli, 2014) even though they still favor adult faces over infant faces (Heron-Delaney, Quinn, Damon, Lee, & Pascalis, 2018). Moreover, recent work demonstrating age-related change in the baby schema effect between adolescence and adulthood (Luo et al., 2020) suggests a largely protracted development of sensitivity to the baby schema. Likewise, the current results do not support a preference for "similar other" or peer preference (e.g., Mahajan & Wynn, 2012), at least not when assessed with a visual preference procedure.

There are several limitations to this study. First, Experiment 2 had a relatively small number of participants, especially when considering the number of infants per age group. Although participant age did not significantly interact with familiarity, there may have been insufficient statistical power to detect such effects. Note, however, that several constraints dampened the collection of a large dataset in Experiment 2, including the difficulty of getting photos of siblings of the infants with relatively neutral expressions (especially younger children) and the necessity of matching of infants on both age and experience. Second, in our design, perceptual experience with child or infant faces was not totally equivalent in terms of the number of identities encountered. Experience with infant faces was mostly provided through nursery care, where infants could have been exposed to 15 or more different infants. Experience with child faces was, however, mostly limited to contact with older siblings, and therefore infants were exposed repeatedly to fewer identities because siblings are more limited in number. Moreover, sibling faces are present with a greater consistency across contexts than infant faces and may co-occur with other important faces (e.g., caregivers). Importantly, siblings are more likely to present up close in front of infants, which facilitates face learning, especially in younger infants (Jayaraman et al., 2015). Consequently, child face learning might have been boosted compared with infant face learning, resulting in the larger novelty preference found in infants exposed to child faces. A difficulty in studying effects of real-world face experience in shaping visual biases in infants is the relative lack of control over their perceptual experience. Recent advances using a head-mounted camera have begun to reveal the actual face experience of infants (Jayaraman, Fausey, & Smith, 2015; Smith, Yu, Yoshida, & Fausey, 2015; Sugden, Mohamed-Ali, & Moulson, 2014; Sugden & Moulson, 2019) and should help in the future to document the visual ecology of infants during the first year of life. In addition, nonhuman primate studies may help to overcome the challenge of controlling postnatal face exposure because, unlike in human infants, facial experience of nonhuman primate infants can be experimentally manipulated (e.g., Simpson, Suomi, & Paukner, 2016).

Overall, the current study reports a trend to look at novel categories of face age from 3.5 to 12 months of age, expanding previous findings investigating infant visual processing of social stimuli. Moreover, presentation of personally familiar faces reversed this pattern of results, although mainly in older infants, likely reflecting the development of recognition of older siblings and further illustrating that both familiarity and novelty biases compete in driving visual attention in infants. Although future studies should further investigate the relation between the real-world experience of infants with personally familiar faces and the emergence of visual biases for a whole-face category, the current observations inform our understanding of the influence of experience in shaping visual biases for infant and child faces.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2021.105174.

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