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The effect of heterogeneous race exposure during infancy

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ABSTRACT

Over the first year of life face processing passes through a period of perceptual narrowing. Such narrowing reflects the closure of a sensitive period associated with a loss of perceptual and neural plasticity. One example of perceptual narrowing is the "other-race" effect (ORE), in which humans more easily recognize and discriminate faces of one's own race than faces different from their own. In the present study, we sought to understand the consequences of having limited racial experience versus exposure to a diverse racial environment with regard to infants' looking preferences to different race faces. We employed a looking time paradigm with 47 infants to examine race preferences as a function of differential exposure to multiple races in the caregiving environment at 4, 6, 8, 10 and 12 months of age. The results revealed: 1) Caucasian and African-American infants were more likely to have homogenous race exposure to caregivers of their own race; 2) there was no difference in preferential looking behavior between infants exposed to a single race versus multiple races at all ages except 10-months (infants exposed to multiple races fixated longer to a race than infants exposed to only one race); 3) infants allocate their gaze more uniformly across the face pairs over time, and 4) infants in this sample did not exhibit own-race preferences. The results suggest that racial exposure to caregivers has little influence on face preference among infants and that face preferences tend to disappear with age. Further studies are needed to evaluate the role of race preference on the child's neurobehavioral and social development.

1. Introduction

Humans are born with the ability to perceive and discriminate a wide variety of stimuli. As they grow older, infants' experience with the world leads them to narrow the perceptual window through which the world is viewed. Perceptual narrowing has often been used to explain many elements of both speech perception (e.g., Kuhl & Rivera-Gaxiola, 2008) and face perception (e.g., Nelson, 2001), and has been associated with neuroplasticity (Pascalis et al., 2005).

Face processing is crucial to social communication, particularly before the onset of spoken language, and by some accounts, perceptual expertise for face processing appears to be acquired as a result of perceptual narrowing – specifically, that the

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perceptual window through which speech/faces are perceived is broadly tuned early in life and narrows with experience. Expertise in face processing is required to gather information about people in the social environment; it is the way in which an infant and his or her caregiver communicate prior to the onset of language (Nelson, 2001), and thus a process that may help to protect the human species (Friendly, Rendall, & Trainor, 2013).

Research on neuroplasticity in infants has often focused on different elements of face processing. For example, in a series of studies it was observed that 6-month-olds can discriminate two human faces from one another as well as two monkey faces from one another, but by 9 months infants lose the ability to discriminate monkey faces (Pascalis, de, & Nelson, 2002). In a follow up study it was demonstrated that 6-month-olds who continue to have experience viewing monkey faces retain the ability to discriminate between them at 9 months, in contrast to infants who did not receive such experience (Pascalis et al., 2005). Importantly, perceptual narrowing is not limited to the so-called “other-species” effect; for example, independent of culture (Kelly et al., 2009), 3- to 6-month old infants are able to differentiate faces of races different than their own, but at 9-months of age discrimination abilities become restricted to their own race (Kelly et al., 2007a, 2007b). This perceptual window stays narrow until adulthood, which gives way for the “other-race effect” (ORE), a phenomenon in which human adults have difficulty discriminating faces within races different from their own.

It is increasingly recognized that infants’ face processing is strongly influenced by their social-visual environment (de Schonen & Mathivet, 1990; Nelson, 2001), and as such, the fine-tuning of their response to faces is largely experience-dependent (Burns, Yoshida, Hill, & Werker, 2007; Heron-Delaney, Wirth, & Pascalis, 2011; Pascalis et al., 2005; Scott & Monesson, 2009). Thus, if infants are exposed to multiple face categories during infancy, they seem to be able to develop a more broadly tuned perceptual system and be able to recognize a broader array of faces (Pascalis et al., 2005; Scott & Monesson, 2009). It has yet to be investigated whether live social interactions with other-race individuals lead to an attenuation of the ORE with longer lasting effects on other-race face recognition at different ages among infants.

The ORE has been reported in infants by 3 months of age and mainly among individuals living in primarily mono-racial environments (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2007a, 2007b; Kelly et al., 2005). Studies have shown that 3-month-old infants exposed to individuals from their own race as well as those from another race show no ORE (Bar-Haim et al., 2006). Moreover, the ORE can be eliminated by exposing a 3-month-old infant to pictures of faces of individuals of other races (Sangrigoli & de Schonen, 2004). There are also changes in the ORE over time. It has been reported that 4-month-olds demonstrate holistic processing of both own- and other-race faces (Ferguson, Kufkosky, Cashon, & Casasola, 2009). However, by 8 months of age, infants process own-race faces, but not other-race faces, holistically (Ferguson et al., 2009), and at 9 months of age, infants are able to recognize own-race faces while showing poor recognition of all other-race faces (Kelly et al., 2009, 2007a, 2007b). Although the ORE appears to be largely influenced by exposure to his or her own race in the infant’s environment, little is known about the specific role of the caregiver’s race on infant’s face preference and related developmental changes in infant’s face preference.

To test this association, we used information on the race of the infants’ set of caregivers as an indicator of his or her heterogeneous racial exposure. We compared this variable to infants’ looking time in a free viewing task as a measure of preference for races. Given that, in terms of ORE development, an infant’s perceptual window for races is adjusted and ultimately set between 6 and 9 months of age (Kelly et al., 2007a, 2007b), we collected data from 4-, 6-, 8-, 10-, and 12-month-olds to more accurately track the influence of experience on preferential looking. It was hypothesized that infants exposed to caregivers of a single race had different race preferences than those exposed to caregivers of multiple races. The study also explored how these race preferences changed over time.

It may be that race preference in infancy matures into the established ability to better recognize faces from one’s own race in adulthood (Meissner & Brigham, 2001). The results of our study will shed light on the naturally developing racial bias that could exist from early environmental exposures. That is, the degree and length of own-race insularity may shape the person’s racial view of the world.

2. Methods

2.1. Participants

Forty-seven infants (22 males) were enrolled in a longitudinal study examining the development of infants’ perception of race. Participants were typically developing infants enrolled when they were 4-months-old and followed up at 6, 8, 10, and 12 months of age. Parents of the infants received informed consent according to guidelines of Boston Children’s Hospital and the study was approved by the Institutional Review Board. Parental education and income information were obtained using the MacArthur Questionnaire (though only 22 parents completed this questionnaire) (MacArthur Research Network on Socioeconomic Status & Health, 2000). The average highest grade (or year) of regular school for the parent signing the consent form was 16.2 years. The proportion of parents within each category of total combined family income for the past 12 months was as follows: 15% earned $5000 through $11,999; 8% earned $12,000 through $15,999; 8% earned $35,000 through 49,999; 8% earned $75,000 through $99,999; 46% earned more than $100,000; and 8% did not know.

At each age, parents were interviewed about the infant’s experience with people whom they interacted most often within a typical week. At the infant’s 4-month visit, the parents were asked about the 5 people the infant saw most often. At subsequent visits, the parents were asked if the infant was exposed to the same people or if there were additional people (up to 3) with whom the infant had interacted frequently. Thus, over the course of the study, a parent could have reported

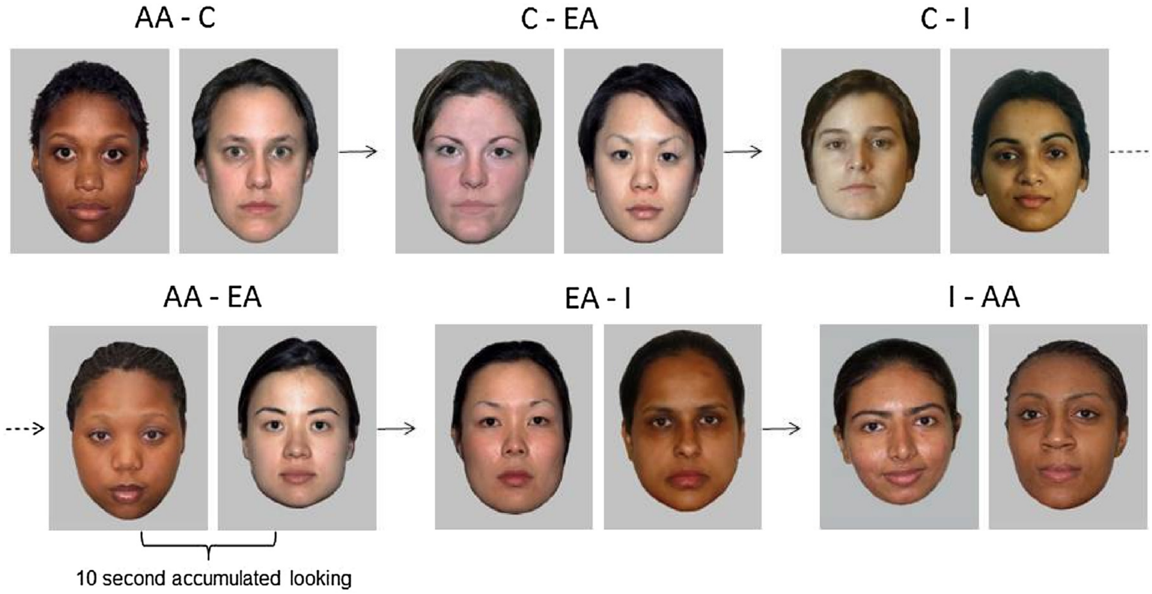

Fig. 1. Example of Free Viewing procedure. Each race-pair was displayed for 10 s, and the order of the pairs was counterbalanced.

that the infant was frequently exposed to up to 17 people. Race information was collected on the people with whom the infant spent the most time. The race options were: Caucasian, African American, American Indian or Alaska Native, Asian Indian, East Asian, Pacific Islander, Multi-race, and Other.

2.2. Experimental design

2.2.1. Stimuli

Color photographs of faces expressing neutral emotions were acquired from several publicly available stimulus sets, including the NimStim set of images (Tottenham et al., 2009), the Eberhardt Face Database (provided by the Mind, Culture & Society Laboratory at Stanford University) and the Productive Aging Lab (Minear & Park, 2004). One hundred and six female faces were used from the aforementioned sources: 24 African American (AA), 28 Caucasian (C), 33 East Asian (EA), and 21 Indian (I) faces. Only females were used due to previous research indicating that infants are sensitive to gender information in faces (Righi, Westerlund, Congdon, Troller-Renfree, & Nelson, 2014). The faces were rated by adult observers on perceived age, attractiveness, and gender with no significant differences on these ratings. All faces were presented on a white background and subtended 11.6° X 12.9° of visual angle.

2.2.2. Procedures

In a sound-attenuated testing room with low lighting, infants were seated on their parent's lap approximately 65 cm away from a Tobii T120 (Tobii Technology AB, Sweden) corneal reflection eye tracking monitor. Monitor specifications included an accuracy of 0.5° of the visual angle and a tolerance of head movements within a range of 44 × 22 × 30 cm. Before the task, infants' looking was calibrated using Tobii Studio (Tobii Technology AB, Sweden) to ensure the eye-tracker was accurately tracking eye gaze. Successful tracking occurred when the infant's gaze followed a red dot that captured looking at 5 tracking points.

After Tobii calibration, a free viewing task was administered to measure gaze location and time spent on each of the faces. E-Prime v1.2 (Psychological Software Products, Harrisburg, PA) was used for image presentation. A trial began by presenting an object on the monitor to attract the infant's attention followed by a face pair on the screen. The faces were presented 8 cm apart. Two pictures of different race faces were presented side by side, and eye gaze data were gathered on the amount of time spent on each of the faces. The infant could look at the screen for up to 10,000 accumulated milliseconds. An experimenter in an adjacent room timed the infant's looking using a stopwatch. A video camera in the testing room allowed for observation in the adjacent room to determine whether the infant was looking at the stimulus. Online coding of infants' looking was used to determine accumulation of presentation time and when to progress on to the next trial. No reliability coding was done and no relations between accumulated times and eye tracking data were examined.

Each infant completed 6 free-viewing trials. Each trial was a pair of faces, such that every race-pair combination was seen and each race seen 3 times (Fig. 1). The order of the trial pairs was counterbalanced across subjects.

Gaze location for both eyes was acquired using the Tobii eye tracker throughout calibration and test. Eye tracking data were sampled at 60-Hz and collected by E-Prime. For each stimulus, pre-determined areas of interest (AOIs) were manually drawn, such that the eye gaze data collected were reported as looking time within the image of the face. Gaze data files were run through a custom-made Python script (Python Software Foundation, http://www.python.org/), which extracted the amount of looking time per image at each trial. The amount of time an infant spent looking at each face image (in milliseconds) was used for all future analyses.

2.3. Measures

2.3.1. Independent variable: single vs. multiple race exposure

The independent variable was constructed based on the parent's report of the race of the infant's caregivers. A caregiver could be the infant's mother, father, nanny, daycare teacher, babysitter, adult sibling, grandmother, grandfather, or extended family member. If a parent reported that the infant's caregivers were all of the same race, the infant was classified as single race exposure (SRE). Conversely, if a parent reported that an infant was exposed to more than one race via his caregivers, the infant was classified as multiple race exposure (MRE). This classification was done at 4-months. At subsequent visits, if a parent reported additional care by a person with a race different from that of previous visits, the infant was reclassified as MRE.

2.3.2. Dependent variable: absolute difference in looking time within pairs of faces in free viewing task

Given our interest in determining whether infants exhibited preferential looking to one face over another, we created a novel dependent measure called *delta gaze.* The *delta gaze* quantifies how uniformly the infant distributed his/her eye gaze between both faces for each 10,000 ms trial. *Delta gaze* was computed using the following formula:

$$deltagaze = \frac{|gazetimeface1 - gazetimeface2|}{totallooking}$$

For example, in Trial 1, an infant looked at the African American face for 2000 ms and the Caucasian face for 6000 ms. Thus, the *delta gaze* was |2000–6000|/(2000 + 6000) = 0.5. If an infant looked at each race in the pair for an equal amount of time, the *delta gaze* was close to 0. Conversely, a *delta gaze* of 1 signified that an infant looked at one race in the face-pair for the entire trial. In other words, a small *delta gaze* implies that an infant is low in "preference" for one of the face pictures because he or she spent the same amount of time looking at both pictures. In contrast, a *delta gaze* close to 1 may mean high preference for one of the two pictures because the infant spent a large amount of time on one picture. Therefore, *delta gaze* is a measure of the infant's preferential looking behavior on one trial. *Delta gaze* is not a measure of the *directionality* of the infant's preference (i.e., which race the infant preferred), as the aim of this study was to assess the overall degree of sustained looking to a race with age, regardless of the race.

2.3.3. Race "preference" variable

A binary variable was coded for each free-viewing trial indicating whether or not the infant "preferred" his or her own race. Preference was determined by which race the infant looked at the most out of the pair of faces on that free-viewing trial. The binary variable was then coded based on whether or not the infant's "preferred" race matched his or her own race. Infants who were Multiracial were excluded from this analysis because there were no pictures of Multiracial women in the free-viewing task, thus making it impossible for Multiracial infants to see their own race in a trial. Additionally, only trials in which the infant's own race appeared in the face pair were included (otherwise, the infant would have been guaranteed to look at a race different than his own in a trial, causing that trial to always be coded as preference for the "other" race).

3. Data analysis

Significance for all hypothesis tests was determined at the $\alpha = 0.05$ level.

3.1. Demographics and frequencies

Demographic characteristics and attrition rates of the infants were calculated using counts and proportions for categorical variables and means/ranges for continuous variables. The number and proportion of infants in the SRE and MRE groups for each age group were tabulated. The frequency and proportion of Caucasians, African Americans and Other (including Multi-Race and East Asian) by SRE and MRE groups were calculated. For the SRE group, the race of the infant and the race of his or her caregivers were compared to determine if the infant's single race exposure was the same as the infant's own race.

3.2. Association between infant's race and exposure

A Fisher's exact test was performed to test the null hypothesis that there is no significant association between the infant's race and his or her race exposure at 12-months. The test was only done at 12-months because if the test was significant at 12-months, it must be significant at previous months because the difference between the SRE and MRE could only get smaller with time (MRE counts can only increase with time; an infant could not "unsee" at later ages the multiple races he or she was already exposed to). The categories for infant's race were Caucasian, African-American, and Multi-race & East

Table 1
Number (percent) of infants in SRE and MRE for each age group.

Single vs. Multiple Race Exposure	4 months	6 months	8 months	10 months	12 months
SRE	30 (63.8%)	28 (59.6%)	28 (59.6%)	28 (59.6%)	26 (55.3%)
MRE	17 (36.2%)	19 (40.4%)	19 (40.4%)	19 (40.4%)	21 (44.7%)

Asian. Multi-race and East Asian were collapsed into one group because East Asian had one infant who was SRE and one infant who was MRE.

3.3. Delta gaze

3.3.1. Delta gaze for each group

Delta gaze was computed for each trial. The mean and standard deviation of the *delta gaze* was calculated for each exposure group and race face-pair. A two-way analysis of variance (ANOVA) was performed to evaluate main effects of exposure (i.e., SRE and MRE) and race face-pairs, as well as interaction between the two, at every age.

3.3.2. Delta gaze over developmental time

A linear mixed-effects model (LMM) was employed to examine the changes of *delta gaze* with age by SRE and MRE groups, collapsed across race face-pairs. LMM analysis was chosen because it provides better within-subject coefficient estimates by pooling information across subjects, without the groups needing to be balanced (Fox & Weisberg, 2015). The model chosen allowed for main effects of age, main effects of exposure, interaction between age and exposure, and random slopes and intercepts for each subject. Mathematically, the model was as follows:

$$deltagaze_{ij} = \beta_1 + \beta_2 exposure_i + \beta_3 age_{ij} + \beta_4 exposure_i age_{ij} + b_{i1} + b_{i2} age_{ij} + \varepsilon_{ij}$$

Where $deltagaze_{ij}$ is the *delta gaze* for the j^{th} of n_i observations in the i^{th} group (i.e., SRE or MRE). β_1 through β_4 are fixed effects coefficients; b_{i1} and b_{i2} are random effects for each exposure group (random intercept and slope, respectively); ε_{ij} is the error for observation j in group i. Akaike Information Criterion (AIC) were used to select the best LMM model for the data.

3.4. Other-race preference

For each age, the proportion of trials that were coded as preference for “other” race was calculated. A two-sided test for proportions was calculated to determine whether the percentage of other-race preferences was different than 50%. That way, for each age, it was determined whether or not infants exhibited own-race or other-race face preferences. Additionally, a Fisher’s exact test of independence for count data was performed to test for associations between caregiver exposure (i.e., SRE or MRE) and other-race preferences (i.e., own-race preference or other-race preference). Odds ratios were calculated as estimates for this test.

3.5. Software

Data were entered and cleaned using IBM SPSS Statistics version 19 for Windows (IBM Corp, Armonk, NY). All analyses were performed using R Version 3.2.3 (R Core Team, 2015). The “foreign” package was used to read in the SPSS files into R (R Core Team, 2015), the “ggplot2” package was used for graphics (Wickham, 2009), and the “lme4” and “nmle” packages were used to perform the LMM analyses (Bates, Maechler, Bolker, & Walker, 2015; Pinheiro, Bates, DebRoy, & Sarkar, 2015).

4. Results

4.1. Demographics and frequencies

The race of the infants was reported by their mothers as follows: 28 (59.6%) Caucasian, 8 (17.0%) African-American, 0 (0%) American Indian or Alaska Native, 0 (0%) Asian Indian, 2 (4.3%) East Asian, 0 (0%) Pacific Islander, 9 (19.1%) Multi-racial, 0 (0%) Other. The Multi-racial infants’ parents were African-American, East Asian, White, or Multi-racial themselves. Table 1 shows the number and proportion of infants with SRE and MRE at each age. Only one infant in the SRE group was exposed to a caregiver of a race different from her own: the infant was categorized as Multiracial and the single race she was exposed to was Caucasian. This means that, for the most part, infants in the SRE group were only exposed to their own race. Table 2 shows the number of infants who came in to the lab for testing, the number of infants who successfully completed the Free Viewing task at each age, and the mean and median age of the infants at test.

Table 2
Attrition rates and descriptive statistics on Free Viewing task per age. The Total column denotes the number of infants who came in to the lab and the Participate column denotes the number of infants who successfully completed the Free Viewing task (i.e., the number of infants who had > 0 ms of total looking time of the infants in the Total column). The subsequent two columns detail the mean (standard deviation in parenthesis) and median age in days of the infants at the visit.

Age	Total	Participate	Mean age	Median age
4	45	26	122.4231 (7.970812)	122.5
6	43	34	182.3235 (9.207114)	182.5
8	34	34	244.5152 (7.620372)	243
10	33	33	305.9697 (7.691248)	305
12	36	36	364.5 (12.57321)	367

Table 3
Number (percent) of infants with SRE or MRE by infant's race for the 12-month-old group. Fisher's exact test showed a significant association between race exposure and infant's race (*p*-value = 0.016).

	Infant's race			
	White	African American	Multi-race & East Asian	Total
SRE	18 (64.3%)	6 (75.0%)	2 (18.2%)	26 (55.3%)
MRE	10 (35.7%)	2 (25.0%)	9 (81.8%)	21 (44.7%)

Table 4
Two-way ANOVAs at each age. The first column denotes the main effect, interaction, and residuals. The next 5 columns denote the *F*-values and degrees of freedom (in parenthesis) for each age. The last 5 columns display the *p*-values for the aforementioned *F*-statistics. The only significant finding is at 10-months: there is a significant main effect of exposure.

	F-value (df)					*p*-value				
	4-mo	6-mo	8-mo	10-mo	12-mo	4-mo	6-mo	8-mo	10-mo	12-mo
Race pair	0.276 (5)	0.733 (5)	0.328 (5)	2.246 (5)	0.529 (5)	0.926	0.599	0.895	0.052	0.754
Exposure	1.561 (1)	0.174 (1)	0.186 (1)	11.111 (1)	2.426 (1)	0.214	0.677	0.666	0.001**	0.121
Race pair X Exposure	1.497 (5)	1.699 (5)	2.240 (5)	0.856 (5)	0.356 (5)	0.194	0.137	0.052	0.512	0.878
Residuals	(142)	(187)	(188)	(184)	(202)					

4.2. Association between infant's race and exposure

Table 3 shows the number and proportion of infants in each race group by the infant's race. A two-sided Fisher's Exact Test showed a significant association between infant's race and homogenous race exposure (*p*-value = 0.016). Caucasian and African-American infants were most likely to have homogenous race exposure. Infants of Multiracial and East Asian categories were exposed to caregivers of several races.

4.3. Association between infant's race and exposure

A two-way ANOVA showed that at every age, there was no significant main effect of race face-pair, main effect of exposure (except at 10 months), or interaction between the two. The *F*-statistics, degrees of freedom, residuals, and *p*-values are tabulated in Table 4. The only significant finding was at 10-months, which showed there was a main effect of exposure ($F(1, 184) = 11.111$, *p*-value = 0.001). MRE infants had a significantly higher *delta gaze* than SRE infants; the difference in *delta gaze* was −0.111. Fig. 2a visually corroborates the aforementioned results. For the most part, all lines representing *delta gaze* over time follow the same trajectory very closely, as proven in the ANOVA results (i.e., no significant differences between the means), except for differences in exposure at 10 months.

4.4. Delta gaze over developmental time

Based on Fig. 2a and b, the average *delta gaze* decreases over developmental time. Fig. 3 shows the *delta gaze* for each infant over time. The model with random intercepts but no random slopes had an AIC of −134.874, while the model with random slopes but no random intercepts had an AIC of −133.521; thus, the model with random intercepts was chosen. There was no significant interaction of age by exposure ($t(118) = -2.046$, *p*-value = 0.0429) and no significant main effect of exposure ($t(118) = 1.322$, *p*-value = 0.1887). However, the main effect of age was significant (-0.018, $t(118) = -2.759$, *p*-value = 0.0067), indicating a statistically significant negative slope of *delta gaze* over developmental time.

4.5. Proportion of other-race preference over time

None of the proportions of other-race preferences (i.e., "preferred" looking at a race not of the infant's own) were significantly different than 0.5 ($\hat{p}_{4mo} = 0.49$, *p*-value = 0.9999; $\hat{p}_{6mo} = 0.46$, *p*-value = 0.5662; $\hat{p}_{8mo} = 0.52$, *p*-value = 0.8262;

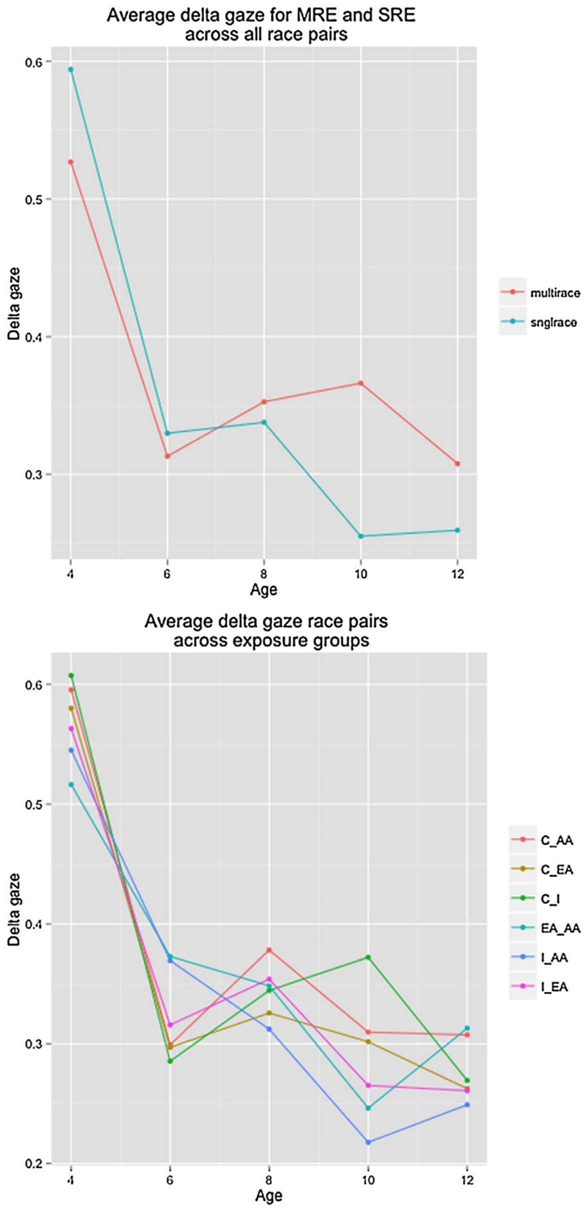

Fig. 2. a *(top) and* Fig. 2*b (bottom)*. These graphs show the average *delta gaze* over developmental time collapsed by groups. Fig. 2a shows *delta gaze* over time for SRE and MRE, collapsed across race pairs. Fig. 2b shows *delta gaze* over time for each race pair, collapsed across MRE and SRE. There are no significant differences in the allocation of looking at the face pairs between the exposure groups (except at 10 months) or between the race pairs, which is corroborated by the ANOVA analysis. At 10-months there is a significant difference in average *delta gaze* between exposure groups: the MRE group has a significantly higher *delta gaze* than the SRE group. Interestingly, the graphs show that infants look more evenly at both faces in each pair over time.

$\hat{p}_{10mo} = 0.6024$, p-value = 0.0790; $\hat{p}_{12mo} = 0.5730$, p-value = 0.2034). In other words, infants were just as likely to look at other-race pictures versus own-race pictures at every age. It is worth noting that after removing Multiracial infants and infants for whom it was impossible to see own-race pictures, the number of infants (with now only 3 trials for each infant) was considerably smaller than for *delta gaze* analyses ($N_{4mo} = 22$; $N_{6mo} = 26$; $N_{8mo} = 28$; $N_{10mo} = 28$; $N_{12mo} = 30$).

Further, there were no significant associations between preference of the infant's own race and whether they were SRE or MRE ($OR_{4mo} = 0.52$, p-value = 0.2905; $OR_{6mo} = 0.52$, p-value = 0.2199; $OR_{8mo} = 1.44$, p-value = 0.4778; $OR_{10mo} = 2.03$, p-value = 0.3830; $OR_{12mo} = 1.70$, p-value = 0.3385). That is, preference for own-race faces is independent of diverse caregiver exposure. Again, we note that the number of observations in each exposure/preference group were quite small, especially for the MRE group, where sometimes there were less than 10 observations in each race preference group.

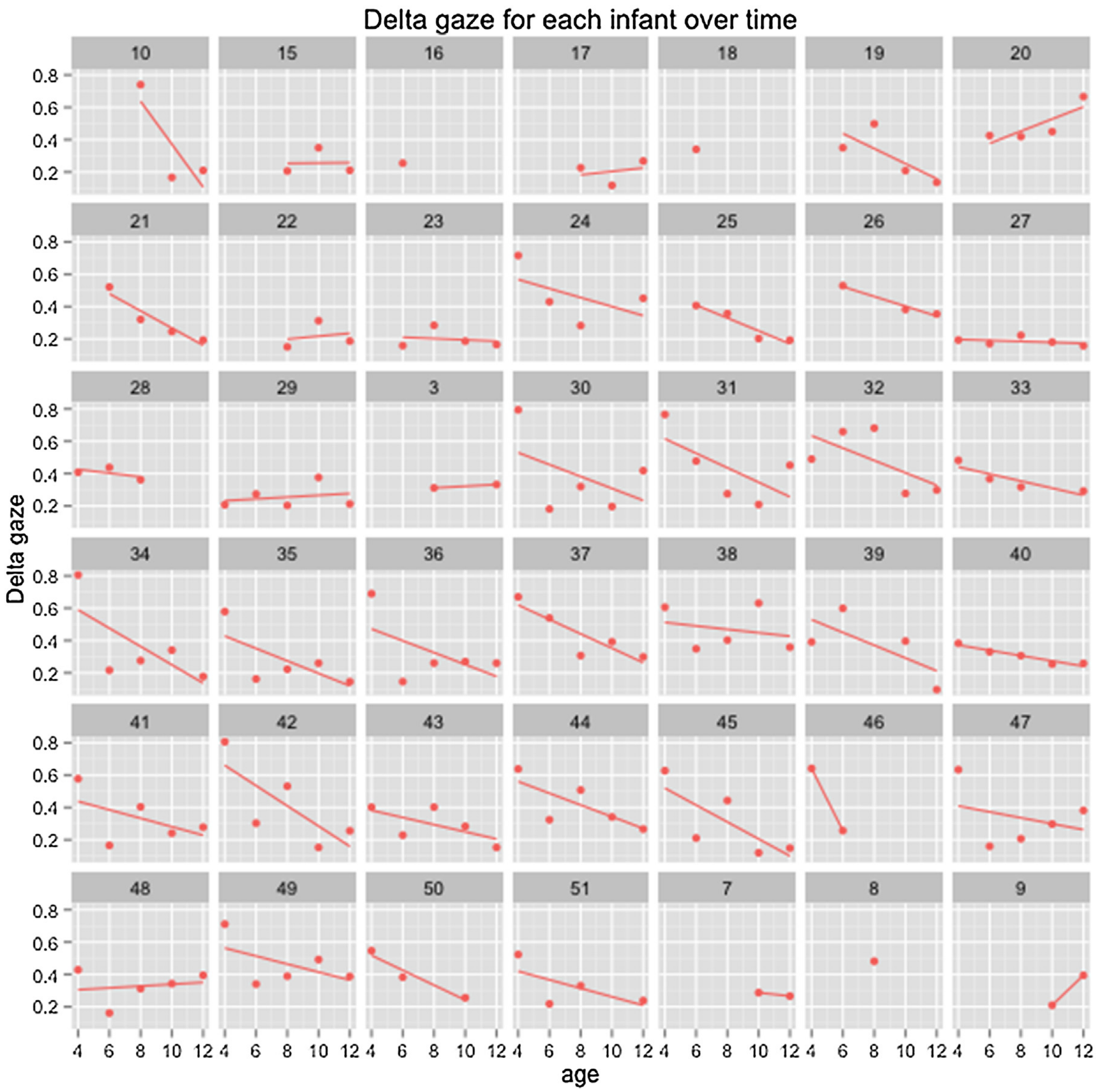

Fig. 3. Trellis display of *delta gaze* over developmental time. Each panel is a scatterplot for one subject. The subject number appears in the strip at the top of each panel. Each point in a scatterplot is the average *delta gaze* at that visit. The line through the points is an ordinary least squares regression line. Most infants' *delta gaze* decreased with time.

5. Discussion

The purpose of the present study was to investigate the development of race preferences in infants between 4 months and 12 months based on the infants' exposure to caregivers of a single race compared to caregivers of several races. The results largely failed to confirm our hypothesis that SRE infants have different race preferences than MRE infants. Indeed, face preferences for infants exposed to caregivers of a single race was not different from those exposed to caregivers of several races, except at 10 months, in which infants split their looking time more evenly across the two faces if they were only exposed to one race (i.e., SRE).

Four-month-old infants in our sample did not exhibit the face preferences documented previously by Kelly et al. (2005, 2009) in 3-month-olds as well as others (Sangrigoli & de Schonen, 2004). However, two recent studies have also failed to find own-race preferences in infants (Gaither, Pauker, & Johnson, 2012; Spangler et al., 2013). Despite methodological differences, these studies offer useful insight to interpret the present results. One possible reason for the discrepancy with some of the prior work (Kelly et al., 2005, 2009; Sangrigoli & de Schonen, 2004) is differential racial diversity at the sites at which the study took place. For instance, infants reared in less racially diverse environments are probably less likely to see faces of another race than children raised in large metropolitan environments (like the infants in the present study). As previously suggested by Spangler et al. (2013), minimal exposure to a diversity of races early in infancy may be sufficient to not develop different preferential looking patterns. Though we divided the infants into ones who had single-race caregiver exposure versus multi-race caregiver exposure, this measure did not account for the wide variety of faces infants are likely to see throughout their day (e.g. at the grocery store, play groups, etc.). Therefore, it is probable that even the infants who had a homogenous caregiver race exposure are actually exposed to a wide array of races in their daily life if they live in a racially diverse area (which may be truer for infants living in large metropolitan areas). As such, the minimal amount of exposure necessary for infants not to develop a race bias may be acquired through exposure to different race faces in each infant's daily life during early infancy. Alternatively, it is also possible that infants who are exposed to a diverse racial environment do not display overall looking time differences, but rather differences in facial scanning patterns, as suggested by Gaither et al. (2012). However, we were not able to capture this level of detail in the present study; as such, we cannot specifically address this hypothesis.

A relevant finding of this study was the significant reduction in face preference during their infancy among all infants, between 4-months and 12-months of age, independent of race exposure or the race pair. The average proportion of time an infant maintained his or her gaze at one picture in the pair compared to the other (i.e., *delta gaze*) was about 0.568 at 4-months and decreased to approximately 0.277 at 12-months. It seems that infants allocated their attention to the faces more uniformly as they got older. After finding that infants look more at faces among distracting stimuli over time, Frank et al. (2014) postulate that infants tend to have similar face preferences, but change their ability to consistently orient and attend to the faces over time. It is known that infant looking patterns and preferences to faces are malleable with experience (Johnson, Dziurawiec, Ellis, & Morton, 1991). For example, infants' scan patterns on faces change considerably in the first year of life (Wilcox, Stubbs, Wheeler, & Alexander, 2013; Kato & Konishi, 2013), and face preferences can even be strengthened by self-produced reaching experiences in 3-month-old infants (Libertus & Needham, 2011). DeNicola et al. (2013) found that infants' ability to hold their attention to a face presented next to a toy was present between 4–8 months of age; however, there was no difference in attention holding between ages. To our knowledge, there has not been a study showing how preference to a face in a pair declines with age. Considering that our study sample consisted of typically developing infants, it is possible to assume that the face preference behaviors may be a marker of typical brain development. Infant development may involve a tendency to explore more faces and thus reduce overall face preferences.

The present study also shows that in a geographic location where infants are exposed to multiple races in their social environments, Caucasian and African-American infants have a more insular racial experience with regards to caregivers (higher percentage of SRE). This finding may be influenced by cultural or socioeconomic differences and is an interesting avenue for future research. Unsurprisingly, Multiracial infants are more likely to be exposed to caregivers of different races. While the present data cannot inform whether children exhibit a racial preference, it is rather interesting that children who are regularly exposed to different races do not exhibit different gaze patterns than those who do not.

Several additions to our variables would further answer the question of how exposure to a diversity of races affects racial biases across development. First, the independent variable, SRE versus MRE, could be more fine-grained. That is, instead of binning infants into only one of two categories of race exposure, the number of races and time the infant was with each of the races could be used as a continuous explanatory measure. Doing this could pinpoint more directly the degree of diversity needed to remove racial preferences in infancy. Additionally, there has been an increasing amount of research using Baby-cams that provide a more rich perspective on infants' behavior (Elwick, 2015). This would also remove the study's reliance on self-report to determine race experience. With self-report there is always the risk of memory biases or failure to report all caregivers. For example, if the child was in day care, it is possible that not all caregivers' information was reported. On a broader scale, as of 2010, the Boston population was predominantly White (53.9%) (United States Census Bureau Boston, Massachusetts, 2015), thus a measure of race homogeneity should extend further than only caregivers to include all racial exposure. Further studies should collect more detailed information about infants' racial exposure in order to be able to more accurately assess the influence of the environment on the emergence of preferential looking to faces of different races. Other methodological additions may also include more fine-grained analysis of looking patterns that include scanning and time-course information.

Future studies should sample based on infant's race so that there is a more uniform representation of infants in each race category. Further, the face pairs shown to the infants should exactly represent the races of the infants in the study. In the current study, to analyze other/own-race preferences, we needed to eliminate all infants that were not represented in the pictures and trials in which the infant's own race was not presented. This left us over-relying on some races (e.g., Caucasian infants) and completely excluding others (e.g., Multiracial infants). This ultimately motivated us to create the variable *delta gaze,* which is independent of which specific race the infants preferred. Additionally, *delta gaze* has the added benefit that it standardizes by the total looking time, in case the infant did not attend to either of the face-pairs for the full 10,000 ms.

Nonetheless, *delta gaze* alone has some limitations. For example, it would be beneficial to know to which race SRE infants looked significantly longer, and if there are preferential tendencies to the single race the infant was exposed to. Again, in the present study this was not evaluated because the sample size was too small in MRE categories and races unevenly represented for own-race preferences to make any meaningful conclusions. Future studies could also evaluate *delta gaze* for subjects who had early exposure versus late exposure to multiple races (i.e., infants who were MRE early on versus infants who changed to MRE later in the first year). We did not do this in the current study because it would mean restricting the data to infants who changed from SRE to MRE over time, and there were only 4 infants who changed exposure groups. Finally, given our dependent measure of *delta gaze* has not been used previously, we are unsure of how normal developmental changes influences its measurement. For instance, the reduction of *delta gaze* time between 4 and 6 months may be driven by infants' developing preference or it may be driven by developmental changes in the visual system.

In conclusion, this study suggests that in this population of infants, race preference is largely independent of exposure to caregiver's race. However, general face preferences steadily decrease over time in the first year of life. Future studies may evaluate face preferences among infants of other populations to assess whether the behavior of uniformly allocating looking time across several faces over time could be considered a marker of typical neurobehavioral development.

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