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Infants' Visual Attention to Own-Race and Other-Race Faces Is Moderated by Experience With People of Different Races in Their Daily Lives

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Infants sometimes differentially attend to faces of different races, but how this tendency develops across infancy and how it may vary for infants growing up with different exposure to racial diversity remain unclear. The present study examined the role of experiences with racial diversity on infants' visual attention to different racial groups (specifically own-race vs. other-race groups) in the first year of life via a large-scale study of infants ($N = 203$; $M_{\text{age}} = 6.9$ months, range = 3–14 months; 70% White, 8% Asian, 5% Black, 12% multiracial, 4% unreported; 14% Hispanic, 86% non-Hispanic) from across the United States. We tested the role of two forms of racial diversity: that of infants' social networks (reported by parents) and that of infants' neighborhoods (obtained from U.S. Census data). Regardless of age, infants looked longer at other-race faces than own-race faces, but this tendency was moderated by the racial diversity of infants' social networks. Infants with more diverse networks looked equivalently long at own-race and other-race faces, whereas those with less diverse networks looked longer at other-race faces. In contrast, infants' looking behavior was not moderated by the diversity of their neighborhoods. Together, our research suggests that exposure to racial diversity in infants' immediate social networks predicts how infants look to faces of different races, illustrating the context-dependent nature of the development of infants' attention to race.

Public Significance Statement

This study suggests that the race and ethnicity of the people infants interact with on a daily basis—rather than the people living in their neighborhoods—influences infants' attention to own-race and other-race faces. Infants with no diversity in their social networks (i.e., those who only interact with members from one racial/ethnic group) looked longer at relatively novel other-race faces compared to relatively familiar own-race faces. Exposure to diversity through close interpersonal relationships, however, equated attention to own-race and other-race faces, highlighting the importance of direct social contact for infants' attention to race.

Keywords: infant cognition, perception, race, diversity, social networks

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Adults often effortlessly encode race information from brief social encounters, with numerous consequences for social cognition and intergroup interactions (Correll et al., 2002; Greenwald & Banaji, 1995). How does this attention to race develop? The earliest evidence of sensitivity to race comes from studies of preferential looking in infancy—that is, young infants' tendency to look longer at faces of one racial group or another when presented with pairs of faces (e.g., 3-month-olds sometimes look longer at own-race[1] than other-race faces; Kelly et al., 2005). Yet, how and when this tendency develops and what factors contribute to its development in diverse societies such as the United States remains unclear. Infant looking sometimes appears to be shaped by experiences with racial diversity: Bar-Haim et al. (2006) found that 3-month-old infants look longer at own-race faces when they are exposed only to own-race people in daily life

[1] We use the term "own-race" as this is the term used in prior research. However, as we (and other researchers) include ethnic categories like Hispanic infants and Hispanic faces as stimuli, a more accurate term would be "own-race or -ethnicity." We chose to use just "own-race" to remain consistent with prior literature.

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but not when they are exposed to people of more diverse racial backgrounds. However, other reports have not found infants' looking behavior to be moderated by experience in this manner (Montoya et al., 2017; Singarajah et al., 2017; Singh et al., 2022). The goal of the present study was to provide a comprehensive examination of how infants in their first year of life look to faces of different races—specifically, their own versus other races—in a sample of infants from communities across the United States that vary widely in their racial–ethnic diversity.

Why Do Infants Look Longer at Some Faces Than Others?

Looking longer at particular faces does not mean that infants are necessarily categorizing faces into conventional racial or ethnic categories or that they prefer (in a social or affective sense) some faces more than others (e.g., Aslin, 2007; Lee et al., 2017; Rhodes & Baron, 2019). Systematically looking at faces from one racial group more than another indicates only that infants are noticing something different between the two faces (e.g., something that correlates with conventionalized racial groups) and for some reason are looking longer at one type of face than another. This reason can reflect a variety of factors, including surprise, social preference, novelty, familiarity, or fear (Aslin, 2007). When infants look longer at either own-race or other-race faces, this pattern is most often interpreted as reflecting the dimension of familiarity versus novelty (rather than surprise, social preference, fear, etc.). For example, infants might look longer at own-race faces because these faces are familiar (and thus provide opportunities to learn about their social group or are easier to process; Howard et al., 2015; Kinzler et al., 2007; Shutts et al., 2009) or longer at other-race faces because these faces are novel (and thus provide more opportunities to learn about faces in general or take longer to process; Bar-Haim et al., 2006; Fassbender et al., 2016; Kelly et al., 2005, 2007; Liu et al., 2015). From this perspective, if infants have sufficient familiarity with faces from multiple racial groups, they might not differentiate their looking by race because although they would still notice the relevant differences between the faces, neither would appear more novel or familiar to them.

Yet, even if such early visual behaviors reflect novelty or familiarity (rather than social preferences or fear) they have nonetheless been hypothesized to be an initial step toward the eventual development of racial biases. For example, the perceptual-to-social linkage hypothesis (Lee et al., 2017) proposes that infants' tendency to look longer at familiar own-race faces contributes to the development of infants' ability to individuate faces of their own race more accurately than faces from other racial groups (with negative consequences for person perception, such as increased stereotyping; Fiske & Neuberg, 1990), as well as the development of more positive associations with their own racial group. Thus, if infants who are exposed to multiple races in their daily lives do not look longer at familiar own-race faces (Bar-Haim et al., 2006; see also Lee et al., 2017), the perceptual–social linkage hypothesis would predict that some of the initial processes leading to racial bias would be blocked among these infants. In this way, exposing infants to people from diverse racial–ethnic backgrounds could be an important way to prevent the development of some perceptual precursors to racial bias (e.g., individuation, Kelly et al., 2009), as well as some early social and affective antecedents to racial bias (e.g., Xiao, Quinn, et al., 2018; Xiao, Wu, et al., 2018). Thus, it is important to determine the extent to which early experience with racial–ethnic diversity does or does not moderate infants' looking to own-race and other-race faces.

How Race Shapes Majority-Race Infants' Looking at Human Faces in Homogeneous Environments

In the first few days of life, infants' looking at human faces does not vary by race (Kelly et al., 2005). At 3 months, however, infants in racially–ethnically homogeneous contexts look longer at faces of their own race. For example, White 3-month-old infants in the United Kingdom, whose parents reported that they had "little or no contact" with people of color, looked longer at White faces than Black, Middle Eastern, or Asian faces (Kelly et al., 2005). Three-month-old infants' tendency to look longer at faces from their own racial group has been replicated with White infants in Israel and Black infants in Ethiopia (Bar-Haim et al., 2006), Chinese infants in China (Kelly et al., 2007; Liu et al., 2015), and White infants in Germany (Fassbender et al., 2016). In each of these cases, the participating infants were from the numerical majority racial group in their local context, and the authors reported that infants had little-to-no exposure to members of other racial–ethnic groups.

Infants' patterns of looking in these racially–ethnically homogeneous environments changes across age. In these contexts, majority-race infants begin to look longer at faces from other-race groups as they approach their first birthday. For example, Chinese infants in China (Liu et al., 2015) and White infants in Germany (Fassbender et al., 2016) shift from looking longer at own-race faces (at 3 months) to looking longer at other-race faces (at 9 months) in longitudinal studies. In both cases, the participating infants continued to have little-to-no exposure to other-race faces across infancy, as confirmed by parent report (e.g., Fassbender et al., 2016 excluded infants if their parents reported that they had ever seen an other-race person—in this study, a Black person).

In sum, 3-month-old majority-race infants in racially–ethnically homogeneous environments look longer at own-race than other-race faces and then shift to look longer at other-race faces at 9-months, perhaps reflecting developmental changes in how infants attend to familiar (i.e., own-race) versus novel (i.e., other-race) stimuli across the first year of life (e.g., Parr et al., 2016; Quinn et al., 2019).

How Exposure to Racial–Ethnic Diversity Shapes Infants' Looking Behavior

Infants who have experiences with racial–ethnic diversity have been proposed to have a different pattern of visual attention to human faces relative to infants growing up in homogenous environments (described above), although only a small number of studies have addressed this issue directly. Bar-Haim et al. (2006) examined how long 3-month-old Black Ethiopian infants raised in Israel looked at Black (own-race) and White (other-race) faces. These Black Ethiopian infants in Israel were raised in absorption centers where they had close social contact with their Black families and White Israeli workers and more generally saw other Black and White people throughout the centers. Rather than showing the tendency to look longer at own-race faces (as same-age Black infants growing up in Ethiopia and same-age White infants growing up in Israel did), these Black infants—who had consistent exposure to both Black and White people—looked similarly long at own-race and other-race faces. Thus, in this case, exposure to other racial groups was related to equivalent looking to own-race and other-race faces. Yet, it remains unclear exactly what kind of exposure to diversity contributes to infants' equivalent attention to own-race and other-race faces. Do infants attend to own-race and other-race faces similarly only when infants have close social contact with people of other racial–ethnic backgrounds? Or is merely seeing racially–ethnically diverse people in the neighborhoods they grow up in sufficient to equate attention?

Two studies with infants in the United States have considered these questions. Singarajah et al. (2017) examined how White and Hispanic 11-month-old infants looked at three pairs of faces—Black–Hispanic, Black–White, and Hispanic–White—and measured infants' exposure to diversity at both the level of close social contact (i.e., the mean hours per day spent with caregivers of the same vs. other race) and at the neighborhood level (i.e., the percent of Black, Hispanic, and White people in their ZIP code). Infants in this study spent the vast majority of their time with own-race and -ethnicity caregivers, so this measure of close social contact was not explored further. Infants' neighborhoods were more diverse, reflecting substantial racial–ethnic variation; however, this variation did not relate to infants' attention to different-race faces. Regardless of racial–ethnic variation in their neighborhoods, infants looked longer at Black than White faces, Black than Hispanic faces, and Hispanic than White faces, with no differences between White and Hispanic infants. One interpretation of these data is that exposure to neighborhood diversity does not moderate visual attention to different-race faces; however, most infants had the same relative proportion of people in their neighborhoods—more White than Hispanic than Black people—so another possibility is that more variation in relative proportion of racial–ethnic groups within neighborhoods would be necessary to detect these effects. More importantly, this study was unable to test the effect of exposure to diversity in infants' close social relationships (due to lack of sufficient variation) and so the question of how the diversity of infants' immediate social experiences (rather than neighborhoods) might shape their looking behavior remains open.

To examine whether exposure to diversity in infants' close social relationships relates to their looking behavior to own-race and other-race faces, Montoya et al. (2017) examined how a majority-White sample of 4- to 12-month-old infants in the United States looked at all possible pairs of Black, East Asian, Indian, and White faces as a function of the racial diversity of their daily caregivers (i.e., whether their caretakers, collectively, belonged a single racial group or multiple racial groups). The authors hypothesized that infants exposed to caregivers from multiple racial groups would look equally long at different-race faces, as in Bar-Haim et al. (2006), while infants exposed to caregivers from only one racial group would display greater attention to one face or the other. Somewhat surprisingly, the authors did not find any moderation by exposure: all infants looked equally long at own-race and other-race faces, regardless of the racial–ethnic composition of their caregivers. One possibility is that, because these infants were tested in a city with substantial racial–ethnic diversity (Boston), even those infants with little diversity in their immediate environments (i.e., infants exposed to caretakers from only one racial group) were exposed to sufficient variation in their neighborhoods that other-race faces did not register as particularly novel to them. This possibility further highlights the importance of measuring and obtaining sufficient variation in infants' exposure to diversity at both the level of close personal contact and neighborhoods in order to disambiguate the effects of each.

To further probe the influence of infants' immediate social environments on their looking behavior—again, in a racially–ethnically diverse environment—a recent study examined how 3-, 6-, and 9-month-old Chinese infants in Singapore attended to own-race and other-races faces based on their exposure to own-race and other-race caregivers (Singh et al., 2022). Regardless of their age or exposure to own-race and other-race caregivers, infants in this study looked longer at other-race (i.e., Indian) faces than own-race (i.e., Chinese) faces—suggesting, as in Montoya et al. (2017), the limited role of infants' immediate social environments on attention. Additionally, 9-month-old infants with other-race caregivers (none of whom were Indian), compared to those with only own-race caregivers, looked even longer at other-race faces than own-race faces. This provides yet another pattern of visual attention that does not clearly map onto the contact hypothesis (i.e., that close social contact with diverse others equates visual attention to own-race and other-race faces): in this study, older infants with exposure to own-race and other-race faces looked even longer at other-race faces, whereas the contact hypothesis would predict that these infants with more exposure to diversity would show less differentiation in their attention to own-race and other-race faces. It is important to note, however, that infants in this study were exposed to other-race caregivers that were not the same race as the other-race stimuli being used; additionally, the racial composition of infants' neighborhoods was not captured as part of this study. Thus, more work is needed to examine how exposure to diversity impacts infant's attention to own-race and other-race faces in this context.

As reviewed above, infant-looking patterns in racially–ethnically homogenous environments (e.g., China, Germany, Ethiopia) appear largely consistent, but it is less clear how attention to race develops for infants growing up in more diverse environments (e.g., Singapore, United States). Specifically, research finds both the presence of an effect—in both directions—of diversity on infants' visual attention to own-race and other-race faces (i.e., diversity mitigates differences in attention, Bar-Haim et al., 2006; diversity magnifies differences in attention, Singh et al., 2022), as well as the absence of it (Montoya et al., 2017; Singarajah et al., 2017), thus limiting our understanding of how experiences with racial–ethnic diversity shape looking patterns across development. However, it is hard to draw conclusions from this body of work given that these studies measured exposure to diversity in either close social relationships (e.g., Montoya et al., 2017; Singh et al., 2022), broader neighborhoods (e.g., Singarajah et al., 2017), or conflated the two (e.g., Bar-Haim et al., 2006). To this end, there is a clear need for a more thorough and multifaceted examination of how experiences with multiple forms of racial–ethnic diversity shape the trajectory of infants' looking to human faces across the first year of life.

The Present Research

The goal of the present research was to provide a more comprehensive understanding of how exposure to racial–ethnic diversity in infants' environments—both their social networks and broader neighborhoods—relates to how infants in the United States look at faces of different races and ethnicities across the first year of life. To provide a more complete and nuanced account of the role that exposure to racial–ethnic diversity plays in infant looking, we expanded prior work by recruiting a sample of infants from across the United

States, instead of from just one city or town, and obtaining detailed information about both infants immediate social environment as well as the demographics of the neighborhoods in which they live.

In addition to recruiting from a more geographically diverse sample, our approach will improve upon prior work in two important ways. First, we go beyond just looking at the demographics of infants' caregivers (e.g., Montoya et al., 2017; Singarajah et al., 2017; Singh et al., 2022) to include a broader range of social relationships by assessing infants' larger social networks. We used The Child Social Network Questionnaire (Burke et al., 2022), which asks parents detailed questions to elicit a list of everyone that their infant interacts with closely (not only caregivers; see also Rennels & Davis, 2008). Second, we concurrently assess the racial–ethnic diversity of infants' neighborhoods through estimates from the U.S. census. Most infants in the United States grow up in diverse neighborhoods: for example, in 2020, the chance of two random people in the same state being different races–ethnicities—the U.S. Census' measure of diversity—was, on average, 61% (U.S. Census Bureau, 2021). Yet, there is also marked variation between states: by the U.S. Census' diversity metric, California's diversity index was 69.7%, while Maine's was 18.5%. Therefore, by sampling from across the United States instead of from only one or a small number of communities, the present research allows us to examine how differing experiences with racial–ethnic diversity relate to variation in infants' looking behavior. Obtaining both of these measures allows us to examine the importance of diversity in infants' social network and their neighborhood—a question not yet thoroughly addressed in the literature.

To provide a more fine-grained test of how looking behavior might change across the first year of life and to extend beyond prior work (which has largely relied on much smaller age ranges), we sampled continuously from infants between the ages of 3 and 14 months, as past work with samples from racially homogenous communities has found that looking patterns change across this age range. In addition, rather than including only infants from the numerical majority racial group as participants, we recruited infants from any and all racial–ethnic backgrounds in our age range.

We predicted that replicating prior work with majority-race infants growing up in homogenous environments (as that is where the most consistent findings lie), we would observe a shift from looking longer at own-race faces to looking longer at other-race faces across infancy. Critically, we expected this pattern to be moderated by infants' exposure to diversity.

Method

Transparency and Openness

All methods and hypotheses were preregistered on the Open Science Framework (OSF): https://osf.io/dnsva/?view_only=9f8047491d4248439efaaef36f5949e9. Any deviations from the preregistered plan are marked transparently below. The raw data and analytic scripts, as well as a video of the study procedure and all stimuli, are publicly available on the OSF: https://osf.io/bphcm/?view_only=f8c39049bfe54358ba1869839885a3e1.

Participants

Two hundred and three full-term infants[2] (sex assigned at birth: 104 female, 99 male) from three to 14[3] months of age ($M = 6.9$ months, $SD = 2.8$, range = 3.0–14.0) were included in the final sample. Parents reported their infants' racial–ethnic identity as the following: monoracial White ($n = 130$), monoracial Asian ($n = 15$), monoracial Black ($n = 9$), monoethnic Hispanic (no race information; $n = 8$), White–Hispanic ($n = 13$), Asian-White ($n = 10$), Black–White ($n = 10$), Asian-Hispanic ($n = 2$), American Indian-Black–Hispanic ($n = 1$), American Indian-White ($n = 1$), Asian-White–Hispanic ($n = 1$), Black–Hispanic ($n = 1$), Black-Pacific Islander–Hispanic ($n = 1$), and Black–White–Hispanic ($n = 1$). To analyze whether infants looked more at own-race versus other race faces, we categorized stimuli as an own-race face if the race of the stimuli was part of an infant's racial identity (as noted by their parent; see the Data Processing section for more details).

Our preregistered sampling plan was to stop data collection on the week that we reached 200 usable participants, so as to have 80% power to detect an effect size of $d = 0.50$ (power analysis assessed using G*Power; Faul et al., 2007; the average effect size of differential looking in past studies was $d = 0.50$–0.60 and the smallest observed was $d = 0.30$; Bar-Haim et al., 2006; Fassbender et al., 2016; Kelly et al., 2005; Liu et al., 2015; Singarajah et al., 2017). Participants were given a $10 Amazon Gift Card for completing the infant session and an additional $5 Amazon Gift Card for completing Network Questionnaire (Burke et al., 2022), which was administered separately to parents. All participants were recruited from November 2021 through April 2022. Participants were recruited and tested online via a virtual platform for developmental research (Rhodes et al., 2020), which allowed for families from all across the United States to participate in an unmoderated fashion. Our final sample includes infants from 40 states and 197 individual ZIP codes.

An additional 75 infants began the study but were excluded from analyses due to several preregistered exclusion criteria: infants not looking at the computer screen for at least half of the time on 75% or more trials ($n = 8$), parental interference on 75% or more trials ($n = 22$), or if a combination of looking away from the screen and parental interference resulted in fewer than 25% of total trials being completed ($n = 1$; see the Exclusion Criteria section). These exclusion criteria were adapted from past work (see Table S19 in the online supplemental materials for a comparison between our exclusion criteria and those of eight papers examining similar research questions). We also excluded premature infants (as this is the norm in infant research due to premature infants' lower maturational age contributing to different capacities for attention, cognition, and language, e.g., Kavšek & Bornstein, 2010; Pena et al., 2012; Perszyk et al., 2018), which was assessed by asking parents if their infant was born more than 3 weeks before their due date ($n = 35$); infants whose videos were too difficult to code (e.g., poor video quality, eyes too far away; $n = 7$); and infants from outside the United States ($n = 2$; this was the only nonpreregistered exclusion criteria[4]).

[2] Greater than 37 gestational weeks.

[3] We preregistered a plan to collect a sample of 3- to 12-month-old infants. Due to the nature of data collection, two infants between 12 and 14 months were collected, and their data were included.

[4] We only included participants from the United States as we relied on U.S. Census data (and the racial–ethnic categories presented therein) to calculate exposure to diversity at the ZIP code level and inform the racial–ethnic categories represented in our stimuli. We felt it would be inappropriate to include the two infants we recruited from outside the states as it is unclear whether those data would be comparable to data from infants living in the United States.

Stimuli

Face stimuli consisted of 24 faces of adult women and men—three Asian,[5] three Black, three Hispanic, and three White per gender—from the Chicago Face Database (Ma et al., 2015). We chose these racial–ethnic categories as they are the most populous in the United States (59.3% White, 18.9% Hispanic, 13.6% Black, 6.1% Asian; U.S. Census Bureau, 2021). The men and women in the Chicago Face Database self-identified as their respective race or ethnicity, and an additional sample of adults rated which racial–ethnic group they perceived each face to belong to as well as how prototypical each face was of their self-reported racial or ethnic category, ranging from 1 (*less typically [race/ethnicity] looking*) to 5 (*more typically [race/ethnicity] looking*). We chose faces that were identified as the same race–ethnicity as the person pictured self-identified (on average, Asian faces were identified as Asian by 97% of raters, Black faces were identified as Black by 99% of raters, Hispanic faces were identified as Hispanic by 85% of raters, and White faces were identified as White by 100% of raters) and those that were judged to be more prototypical of their racial–ethnic category ($M_{\text{Asian}} = 3.80$, $M_{\text{Black}} = 4.06$, $M_{\text{Hispanic}} = 3.61$, $M_{\text{White}} = 4.32$).

Faces were presented in gender-matched pairs (e.g., Asian Woman–Black Woman), and pairs were matched on perceived age and attractiveness (as assessed by the Chicago Face Database's adult raters' estimation of the age and attractiveness of the faces). The stimuli were paired so that infants saw all possible combinations of race–ethnicity pairs for both women's and men's faces (see OSF for all stimuli pairs). Because families participated at home from their personal computers, we cannot report the precise locations of the stimuli on participants' individual screens; however, the study was set up such that the stimuli would be presented on either side of the screen (each face amounted to about 35% of the display width) and separated by a blank gap in the middle (about 25% of the total display width, see Figure 1).

Procedure

Participants were recruited online via a virtual platform for developmental research (Rhodes et al., 2020) that contains basic demographic information for all recruited participants (e.g., age, ZIP code) and facilitates remote participation in research. From there, parents provided informed consent for their infants' participation and were instructed on how to hold their infant for the duration of the study, including to keep their eyes closed (see OSF for full video of study procedure).

The first phase of the experiment was a calibration phase where infants were shown a series of attention-getters (colorful, musical, moving shapes) on the left and right sides of the screen twice for 2 s each. The purpose of this phase was to calibrate the coders to what an individual infant looked like when they were looking at the left and right side of the screen. All infants looked left and right at least once in this calibration phase.

After the calibration phase, infants were shown the 12 face pairs, one at a time, for 6 s each. The order of the pairs and which face in a pair was on the left versus right side of the screen were randomized across participants. Attention-getters were shown in the center of the screen for 3 s between each pair of stimuli in order to continually draw infants' attention back to the computer (see Figure 1 for visualization of study methods).

At the end of the infant portion of the session (i.e., after infants had seen all 12 trials), parents were asked to report demographic information about their infant (e.g., infants' race, sex, ethnicity), as well as about themselves and their partner/significant other who shares caregiving responsibilities, if applicable (e.g., race, gender, ethnicity, political orientation). For our questions probing racial–ethnic identity (of infants, parents, and partners), parents could select as many of the following six options as applied: (a) American Indian or Alaska Native, (b) Asian, (c) Black or African American, (d) Hispanic or Latino, (e) Native Hawaiian or Other Pacific Islander, and (f) White. After reporting demographic information and submitting the survey, parents were invited to complete an additional survey about the people their infant sees in a typical week to assess their infants' social network (The Child Social Network Questionnaire; Burke et al., 2022). Parents had the option to complete this survey at the end of the session or at a separate time.

Exclusion Criteria

Infants' data were excluded, at the trial-level, in cases in which the infant themself attended to the screen for less than 3 s (less than 50% of the total trial duration) or the parent attended to the screen for 3 s or more seconds (50% or more of the total trial duration). If an infant had 9 trials (of the 12 total; 75%) excluded for either or a combination of the exclusion criteria, all of that infants' data were excluded from analyses ($n = 31$, as mentioned in the Participants section). This resulted in 2,158 trials of data from 203 infants—an average of 10.6 trials per infant.

Coding

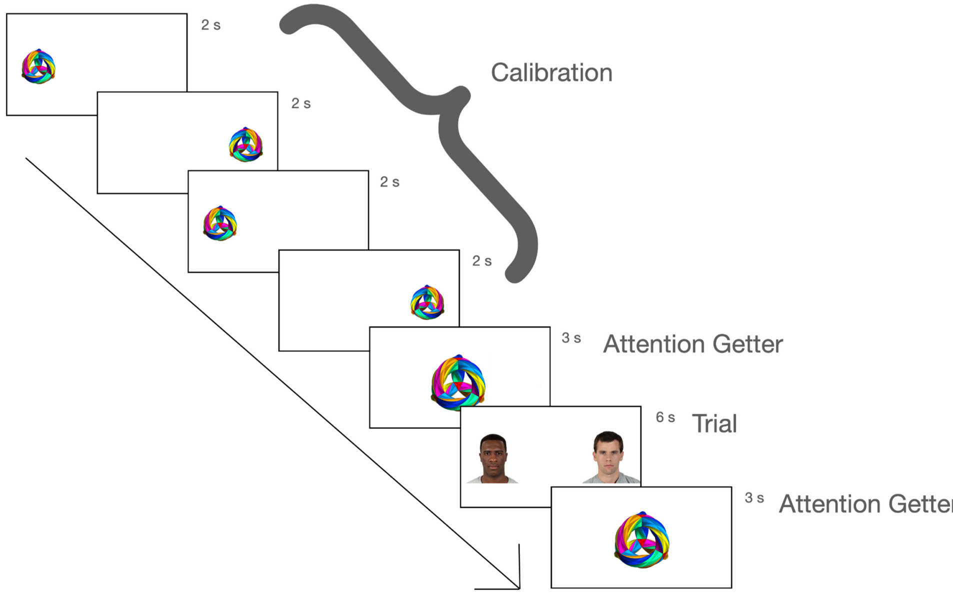
We used the platform Datavyu to code all videos at the level of individual frames (Datavyu Team, 2014). Datavyu coders could only see the infants' faces and their parents' faces (if parents were present); thus, coders were blind to which pair of faces was displayed in each trial, as well as to which face appeared on which side of the screen. A team of four undergraduate research assistants coded the 203 videos for where the infant was looking during the calibration phase and for all valid trials: left, right, center, offscreen or indeterminant. In instances in which a frame was deemed indeterminate, the first author examined the video and resolved coding (left, right, center, or offscreen) for all but two instances where the frames were too blurry to determine location of looking. These data—and, specifically, the left and right coding classifications—are the primary data used in all analyses reported below. One-fourth of all videos ($n = 51$) were randomly selected to be reliability coded for the infant's looking direction by the lead author or an undergraduate research assistant who had not previously coded that subset of videos. Intraclass correlations (ICC; absolute agreement) were calculated for the total time spent looking at the left face of each trial, the total time spent looking at the right face of each trial, and the proportion of time spent looking at the left face of each trial (total trials = 584). All three correlations were excellent, ICC(3,1) = .93, ICC(3,1) = .94, and ICC(3,1) = .91, respectively. For more information about our coding procedure, see Section 0 in the online supplemental materials.

Data Processing

Similar to prior work on infant looking, we focus on attention holding (i.e., how long infants look at each face) rather than attention

[5] Asian face stimuli were all of East Asian descent.

Figure 1
Visualization of Study Methods



Note. The above figure displays the calibration phase and one example trial (of the 12 total trials that infants could see). The order of trials, as well as the left-right orientation of face pairs on the screen, was randomized across participants. We had two different attention-getters to increase the likelihood of recapturing attention throughout the study (see OSF for full study procedure and all attention getters used). The displayed shape is an animation by Greg Egan showing Klein's Quartic Curve in 3D. The faces are drawn from the Chicago Face Database. Adapted from "The Chicago Face Database: A Free Stimulus Set of Faces and Norming Data," by D. S. Ma, J. Correll and B. Wittenbrink, 2015, *Behavior Research Methods, 47*(4), pp. 1122–1135 (https://doi.org/10.3758/s13428-014-0532-5). Copyright 2015 by the Psychonomic Society. Adapted with permission. See the online article for the color version of this figure.

orienting (i.e., how long it takes for infants to look at each face; e.g., Hunter & Markant, 2021; Prunty et al., 2020). In order to calculate infants' attention to own-race and other-race faces, we first calculated the total time (in milliseconds) spent looking at the left and right sides of the screen for each trial. Based on which face pair was displayed for each trial and which side of the screen each face was presented on, we calculated the total time infants spent looking at a particular face for each trial (e.g., for an Asian-Hispanic trial, we extracted the total time spent looking at the Asian face and total time spent looking at the Hispanic face). To determine the total time (in milliseconds) spent looking at own-race versus other-race faces, we then coded whether each face shown was an own-race or an other-race face relative to each individual infant. A face was coded as own-race if the race of the face was represented in the infant's racial identity (as indicated by parent report) and was coded as other-race otherwise. We chose this method of classification, rather than assuming infants' racial identity from their parents', as not all parents provided information about their own racial identity(s). However, we recognize that this method may not reflect the experiences of some of our infants (such as adopted infants or multiracial infants from single-family homes with monoracial parents, which constituted up to 4% of our sample).

To further illustrate our coding of own-race versus other-race faces, we provide examples for two hypothetical infants: a monoracial White infant and a biracial Black–White infant. For monoracial White infants, White faces were coded as own-race, while Asian, Black, and Hispanic faces were coded as other-race. For a biracial Black–White infant, both Black and White faces were coded as own-race, and Asian and Hispanic faces were coded as other-race. On trials assessing total time spent looking at own-race versus other-race faces, we only included trials where infants saw an own-race and an other-race face. That is, we excluded data from trials in which infants saw faces from two other-race categories (e.g., for monoracial White infants, Black-Hispanic trials; for Black–White biracial infants, Asian-Hispanic trials) and, for multiracial infants, trials in which infants saw faces from two own-race categories (e.g., for Black–White biracial infants, Black–White trials). This resulted in 1,125 total trials from 203 infants, an average of 5.5 valid own-race versus other-race trials per infant.

Data Quality Check

To assess the quality of our data, we examined (a) the average number of valid trials an infant supplied (not just the subset of trials for our analysis of attention to own-race versus other-race faces), as well as (b) how the average time an infant spent looking at the screen changed as a function of infants' age and the trial order (and the face pairs represented in it), and (c) the relationship between trial order and attention to own-race and other-race faces. As noted above, infants completed 10.6 trials out of 12 possible trials; on these trials, they looked for an average of 4.79 s per trial out of 6 possible seconds. With respect to age, there was a small positive correlation between infants' age and the number of trials completed, $r(201) = 0.15$, $p = .030$ (see Figure S2 in the online supplemental materials), as well as the average time spent looking at trials, $r(201) = 0.20$, $p = .005$ (see Figure S3 in the online supplemental materials). In general, and unsurprisingly, infants were less likely to complete trials that were presented at the end of the survey compared to the beginning, $r(10) = -5.43$, $p < .001$ (see Figure S4 in the online supplemental materials), but because the trials were presented in a randomized order across participants, there was no difference in the number of infants who completed each type of trial across the sample, $\chi^2(77) = 84$, $p = .274$ (see Figure S5 in the online supplemental materials).

When looking at just the trials where an own-race and an other-race face were shown to infants, infants completed 87.5% of the possible trials and they looked at these trials for an average of 4.80 s out of 6 possible seconds. With respect to age, there was a small positive correlation between infants' age and the percent of own-race and other-race trials they completed, $r(201) = 0.18$, $p = .011$. We found no correlation between trial order and how long infants looked at own-race faces, $r(10) = -0.42$, $p = .178$, or other-race faces, $r(10) = -0.39$, $p = .206$. Therefore, we are confident that our data is high quality.

Exposure to Racial–Ethnic Diversity

We measured infants' exposure to racial–ethnic diversity at two levels: that of their social network and that of their neighborhood.

Social Network Diversity

Social network diversity can be described by (a) the absolute presence of different social categories in the network and (b) how diverse the network is relative to the child. Here, we focus on the former (i.e., the absolute presence of different social categories): we refer to this as network racial–ethnic diversity, and it is derived using a calculation of entropy, described in detail below). For analyses involving the latter, see Section 3C in the online supplemental materials.

The Child Social Network Questionnaire. To assess infants' social network diversity, we administered The Child Social Network Questionnaire (Burke et al., 2022). 72% of parents completed this questionnaire for their infant, which was adapted to be administered asynchronously on the virtual platform. The survey is administered in two parts. First, parents answer a series of questions to indicate the different people that their infant interacts with on a regular basis (i.e., "Who did your infant interact with in the past 2 weeks?"). These questions were used, first, to probe the size of infants' social networks, the median of which was 8 (min = 2, max = 32). Importantly, infants' attention to own-race and other-race faces was unrelated to the size of their social network, *p*s $> .297$. Next, parents filled out a demographic form for each of the people listed in the first part, identifying their gender, race, and age, as well as other characteristics; on average, parents provided demographic information for 97% of the people listed as part of the social network. This second set of questions was used to assess the racial–ethnic composition of infants' networks. Given that data collection occurred during the COVID-19 pandemic, we also used it to assess the nature of infants' interactions (i.e., online, in-person, or a mix): infants interacted with the vast majority of their social networks in person (74.6%), followed by both in person and online (16.1%), and rarely had only online contact (9.3%). These data were also collected over a 5-month period where the pandemic surged (omicron variant); however, participation date was unrelated to the size of infants' social networks, $r(145) = -0.09$, $p = .300$.

Six parents completed the survey but did not report race information for more than 25% of their infants' social network; thus, we excluded those infants from analyses involving social network diversity. A list of these questions is available at https://osf.io/bphcm/?view_only=f8c39049bfe54358ba1869839885a3e1. While The Child Social Network Questionnaire describes many aspects of infants' social networks, the present study focused on network racial–ethnic diversity, which we describe in detail below.

Network Racial–Ethnic Diversity. Network racial–ethnic diversity was calculated using entropy, a metric used in the social sciences to describe the relative presence of different social categories such that both the total number of racial–ethnic groups and more equitable distributions of those groups result in greater entropy (Proops, 1987). In order to calculate the racial–ethnic entropy of infants' networks, each person in the network needs to be classified by a discrete racial–ethnic category. The categories that were used to calculate entropy were the following: American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino, White, Native Hawaiian or Other Pacific Islander, and Other (fill in). As a reminder, parents could select multiple choices when identifying the demographic characteristics of people in infants' social networks; thus, we incorporated an additional category into the entropy calculations: "multiracial."[6] To illustrate what this entropy score looks like, we provide some examples. Infants with only one race represented in their social network (e.g., all White people OR all Black people) would receive the lowest possible score of 0; there is no diversity of categories represented. Infants with three Black people and one Hispanic person (two unequally represented groups) would receive a score of 0.81. Infants with two White people and two Asian people (two equally represented groups) would receive a score of 1. Infants with two Black people, two White people, and two multiracial people (three equally represented groups) would receive a score of 1.58. The entropy score does not take into account the infants' own race; it merely describes the composition of racial–ethnic groups represented in the network.

There was a strong skew in infants' social network entropy such that almost half of the infants had only one racial or ethnic group represented in their social networks and therefore no diversity in their network (i.e., an entropy value of 0), while the remaining infants' social network entropy had two or more racial or ethnic groups in their network (i.e., entropy values between 0.31 and 1.78; see Figure S6 in the online supplemental materials). Given this strong skew, we dichotomized the social network entropy variable into two groups: infants with an entropy score of 0, who had only one racial–ethnic group represented in their social networks (i.e., no diversity group, $n = 59$),[7] and infants with an entropy score greater

[6] This measure of entropy requires all individuals to be identified as one category, rather than multiple (as we were able to when determining which stimuli were own-race and other-race faces for multiracial infants). We chose "multiracial" rather than separate codes for all multiracial identities to not overinflate infants' entropy scores.

[7] All but two infants were the same race-ethnicity as the single group represented in their social network. These two exceptions were the following: one Black-Hispanic infant who had only Black people in their social network and one Black infant who had only White people in their social network.

than 0, who had more than one racial or ethnic group represented in their social networks (i.e., any diversity group, $n = 88$).[8] This distribution—of one large group of infants with no diversity and another group with any diversity—is similar to a sample of infants collected prior to COVID-19 (see Burke et al., 2022).

Overall, 60% of infants whose parents provided social network information ($n = 147$) had any diversity in their social networks, meaning they reported that their infant interacted with more than one racial–ethnic group. Monoracial white infants ($n = 97$) and monoracial infants of color ($n = 22$) were equally likely to be members of the any diversity group, 51% vs. 55%; $t(31) = 0.34$, $p = .739$, but multiracial infants ($n = 28$; $M = 96\%$) were significantly more likely to be part of this group than monoracial infants, $n = 119$; $M = 51\%$; $t(117) = 7.75$, $p < .001$.

Neighborhood Diversity

All families reported their ZIP code; one infant's ZIP code was not included in the U.S. Census data, and so we swapped their ZIP code for a neighboring ZIP code that was included. We used the package "tidycensus" (Walker et al., 2021) in R to obtain the 2020 U.S. Census American Community Survey (ACS), a 5-year survey that includes estimates of the neighborhood-level racial demographics for each ZIP code in the United States. The ACS estimates the racial–ethnic demographics of a ZIP Code from a survey that asks people to identify their racial identity (American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White) and ethnic identity (Hispanic or Latino, not Hispanic or Latino). The ACS reports data for the total population size of a ZIP code as well as for each subgroup of people identifying with the following racial–ethnic identities in that ZIP code: monoracial American Indian or Alaska Native, Asian, Black, Native Hawaiian or Other Pacific Islander, White, as well as White–Hispanic, Black–Hispanic, and Asian–Hispanic, and Hispanic (all people who identify as Hispanic, e.g., Asian–Hispanic, Black–White–Hispanic). While there are multiple ways to describe neighborhood racial diversity, here we focus on the racial–ethnic entropy of infants' neighborhoods (see Section 3C in the online supplemental materials for analyses involving relative presence of other-race members in infants' neighborhood).

Neighborhood Racial–Ethnic Diversity. The identical method used to calculate infants' Social Network Racial Diversity was used to calculate their Neighborhood Racial Diversity—entropy—which describes the relative presence of different racial groups in infants' neighborhood (rather than in their network). To reiterate, a score of 0 indicates that there is no diversity of racial categories (i.e., all of the people in the neighborhood are the same race), whereas higher entropy scores indicate a greater representation of different racial–ethnic groups and a more equal distribution of those racial–ethnic groups. For example, an infant who lives in a neighborhood where 70% of residents are White, 20% are Black, and 10% are Asian would receive a score of 1.16, whereas an infant who lives in a neighborhood where 25% of the residents are White, 25% are Black, 25% are Asian, and 25% are Hispanic would receive a score of 2.

Overall, infants had an average Neighborhood Racial Entropy score of 1.09. This score was lower among monoracial White infants ($n = 130$; $M = 0.98$) than monoracial infants of color, $n = 32$; $M = 1.29$; $t(56) = 4.03$, $p < .001$, and similar for monoracial infants of color ($n = 32$; $M = 1.29$) and multiracial infants, $n = 41$; $M = 1.27$; $t(56) = 4.03$, $p < .001$.

For the rest of this article, any reference to diversity, at both the network and neighborhood level, will refer to the entropy calculation. Network Racial–Ethnic Diversity will refer to the network entropy calculation and Neighborhood Racial–Ethnic Diversity will refer to the neighborhood entropy calculation.

Analytic Strategy

We report analyses for our two main research questions as outlined in our preregistration (how infants look at own-race and other-race faces across the first year of life and whether exposure to diversity in their social network or neighborhood moderates any difference in visual attention; https://osf.io/dnsva?view_only=9f8047491d4248439efaaef36f5949e9).

Before describing the details of our models, we situate our analytic approach with respect to prior work. Prior work on how infants attend to own-race and other-race faces has typically averaged how long each infant looks at own-race versus other-race faces across trials, calculated a single proportion for each infant (i.e., of own-race or other-race looking), and tested these proportions against chance using *t*-tests or similar analyses (e.g., Bar-Haim et al., 2006; Singh et al., 2022). We improve upon these past statistical techniques in two ways by using advancements in statistical programming over the last several years. First, we analyze our data using linear mixed effects models, which allow us to retain data from all trials for every infant, rather than averaging at the participant level (see Muradoglu et al., 2023 for a detailed summary of mixed models for research on cognitive development). We include a random intercept for infant ID in these models, which functionally allows the intercept for each participant to vary and accounts for the nonindependence of an infant's data from multiple trials. Second, we are prioritizing analyses with total looking time as our main dependent variable (as opposed to proportion looking time). Analyzing the data with total looking time to own-race versus other-race faces as our dependent variable, rather than proportion of looking time to each group, allows us to examine how long an infant looks at own-race and other-race faces separately. If we modeled our data as proportion and found a significant effect of age such that infants directed more of their attention to other-race faces with age, for example, we would not know if that was because of older infants looking longer at other-race faces (and similarly at own-race faces), less at own-race faces (and similarly at other-race faces), or some combination thereof, as all these possibilities result in the same observed effect—that is, directing more proportional time to other-race than own-race faces. Using total time, rather than proportion, allows us to directly tease apart these possibilities. Our results are the same, however, when using proportion of time as our dependent variable; we report these findings in Section 5 in the online supplemental materials.

Our main analyses are modeled as linear mixed-effects models with total time in milliseconds spent looking at a face regressed on infants' age in days, which face they are looking at (*own-race* = 1, *other-race* = 0), and the interaction between these two variables. We included a random intercept for the face pair infants were

[8] For infants with more than one racial-ethnic group represented in their social network, 61 (69%) of these infants were identified as monoracial and 27 (31%) of these infants were identified as multiracial.

looking at and a random intercept for participant. For models examining the effects of social network or neighborhood racial–ethnic diversity, we additionally include a fixed effect for the respective diversity measure that is interacted with all other fixed effects. All predictors are mean-centered to allow for the interpretation of lower order effects. As a measure of effect size, we provide standardized coefficients. That is, we *z*-score the continuous predictors (infants' age, neighborhood diversity) and dependent variables (time in milliseconds) but not the dichotomous variables (own-race vs. other-race face, social network diversity). Thus, coefficients on age and neighborhood diversity can be interpreted as the fraction of a standard deviation by which the dependent variable (time spent looking at a face) changed in response to a 1 *SD* increase in the relevant predictor variable. The coefficients on dichotomous variables (e.g., whether a face is an own-race or other-race face, social network diversity) can be interpreted as an approximate equivalent to Cohen's *d*s (e.g., Robinson & Lubienski, 2011). We followed up all of our mixed models with an analysis of variance to determine whether terms in our model improved model fit. If including age did not improve our model fit, we removed age as a predictor from the model.

We include an additional set of models in the online supplemental materials, the majority of which were preregistered (see Sections 3A-E and 4A-B in the online supplemental materials for more details) while one was not (see Section 7A in the online supplemental materials for more details). We briefly summarize the results of these analyses in the Supplemental Analyses section.

Results

Infant's Visual Attention to Own-Race Versus Other-Race Faces by Age

Infants looked longer at other-race than own-race faces, regardless of age, $b = -288.1$, $SE = 54.5$, $p < .001$ (see Figure 2), amounting to a 0.22 *SD* gap between how long infants look at other-race versus own-race faces. Contrary to our hypothesis and past research (though consistent with Singh et al., 2022), we did not find any evidence of a shift across age from more own-race to more other-race looking; indeed, there were no main, Wald $\chi^2(1) = 3.40$, $p = .065$, or interactive, Wald $\chi^2(1) = 0.05$, $p = .817$, effects of age.

For all further reported analyses, we only mention age as a predictor if it improved model fit. See Section 2 in the online supplemental materials for models with age included.

Effects of Exposure to Racial–Ethnic Diversity

Next, we use two aspects of infants' exposure to racial–ethnic diversity to examine whether such exposure attenuates the greater attention to other-race than own-race faces observed in the overall sample: the racial–ethnic diversity of infants' social network (obtained for only 147 [72% of] participants) and the racial–ethnic diversity of infants' neighborhood (obtained for all 203 participants). As described above, our measure of social network diversity was dichotomous to account for the skew in the data: we grouped infants by whether they had no diversity in their social network (entropy = 0; $n = 59$) or any diversity in their social network (entropy > 0; diversity, $n = 88$). To measure diversity of infants' neighborhoods, we examined the racial–ethnic entropy in infants' neighborhoods as a continuous (i.e., untransformed) variable, since there was no meaningful skew in the data.

Social Network Diversity

Infants with no diversity in their social network looked longer at other-race than own-race faces, $b = 460.9$, $SE = 102.8$, $p < .001$, whereas infants with any diversity in their social networks looked equally long at own-race and other-race faces, $b = 62.7$, $SE = 82.6$, $p = .448$ (interaction between own-vs. other-face and social network diversity Wald $\chi^2(1) = 9.12$, $p = .003$; see Figure 3 Panel A).

Neighborhood Diversity

We found no main, Wald $\chi^2(1) = 0.04$, $p = .851$, or interactive, Wald $\chi^2(1) = 0.00$, $p = .988$, effects of neighborhood diversity on infants' looking toward own-race or other-race faces (see Figure 3, Panel B for visualization). For further details of these analyses (e.g., regression table), see Section 2 and Table S3 in the online supplemental materials.

Supplemental Analyses

In this section, we provide a brief summary of findings from each of the remaining preregistered research questions and analyses described in the online supplemental materials to provide readers with a high-level takeaway of these patterns. First, we tested whether infants' tendency to look at own-race versus other-race faces is moderated by their own race (as identified by their parents and grouped into one of five categories: monoracial Asian, monoracial Black, monoethnic [no race reported] Hispanic, monoracial White, and multiracial). These analyses revealed that monoracial Asian, monoracial White, and multiracial infants look longer at other- than own-race faces, replicating the findings from the overall sample reported above; there were very few Black and Hispanic infants ($n = 9$, $n = 8$, respectively) and no model terms reached significance for these groups (see Section 3A in the online supplemental materials).

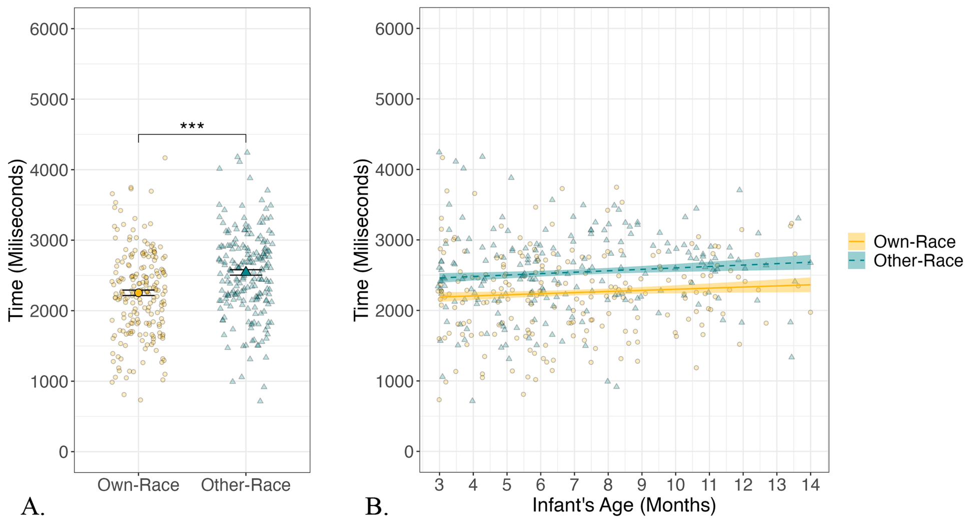
Second, we tested whether infants look similarly long at own-race versus other-race faces when they have any other-race members in their social networks (vs. only own-race members)[9] or have a higher proportion of other-race people in their neighborhoods. These analyses revealed an effect for social network diversity fairly consistent with that presented in Figure 3 Panel A: infants with other-race people in their social network looked equivalently at own-race and other-race faces, though this pattern was most clear for infants younger than 9.30 months old (see Section 3B in the online supplemental materials). As with the measure of neighborhood diversity reported above, these analyses revealed no effect of neighborhood diversity.

Third, we tested whether infants systematically looked at specific races within each face pair (e.g., Asian-White, Black–Hispanic). We found that infants tended to look longest at Black faces, then

[9] The difference between analyzing the data with respect to entropy versus any other-race can be most clearly seen in the social network analysis for multiracial infants. For monoracial infants, entropy and any other-race people in their social networks will be the same. Multiracial infants could have a diverse social network with respect to entropy (more than one racial group represented in their social network) but not a diverse social network with respect to other-race (e.g., all those people share a racial identity with the infant).

Figure 2

Infants Visual Attention to Own-Race Versus Other-Race Faces



Note. Panel A depicts infants looking time at own-race and other-race faces. Large dots are estimated means, error bars are standard errors, and small dots are horizontally jittered data points averaged at the participant level. Panel B depicts infants looking time at own-race and other-race faces by age. Lines are predicted effects, ribbons are standard errors, and small dots are data points averaged at the participant level. See the online article for the color version of this figure.

Hispanic faces, then White faces, and least at Asian faces (see Section 3C in the online supplemental materials).

Fourth, we examined how infants' own racial identity might change the observed effect of infants' looking at faces of different races (i.e., longer looking to Black than Hispanic than White than Asian faces, described above). This pattern held for White infants, with other racial groups showing less pronounced patterns (see Section 3D in the online supplemental materials).

Fifth, we examined whether the relative proportion of pairs of racial groups in infants' neighborhood moderates how long infants look at paired faces of those races (e.g., whether the relative proportion of Asian and Black people in their neighborhoods moderates infants' attention to the Asian–Black pairs); this measure largely did not predict infants' attention to different-race faces (Section 3E in the online supplemental materials).

We also included three exploratory analyses; the first two were preregistered while the last was not. First, we examined whether parents' political ideology—a proxy for racial attitudes (Jost et al., 2003; Stern & Axt, 2021)—moderated infants' longer attention to other-race versus own-race faces and found no effect of parents' political ideology on infants' attention (Section 4A in the online supplemental materials). Second, we examined whether stimuli gender moderated infants' attention to own-race versus other-race analyses (e.g., Quinn et al., 2008), but did not find any such effect (Section 4B in the online supplemental materials).

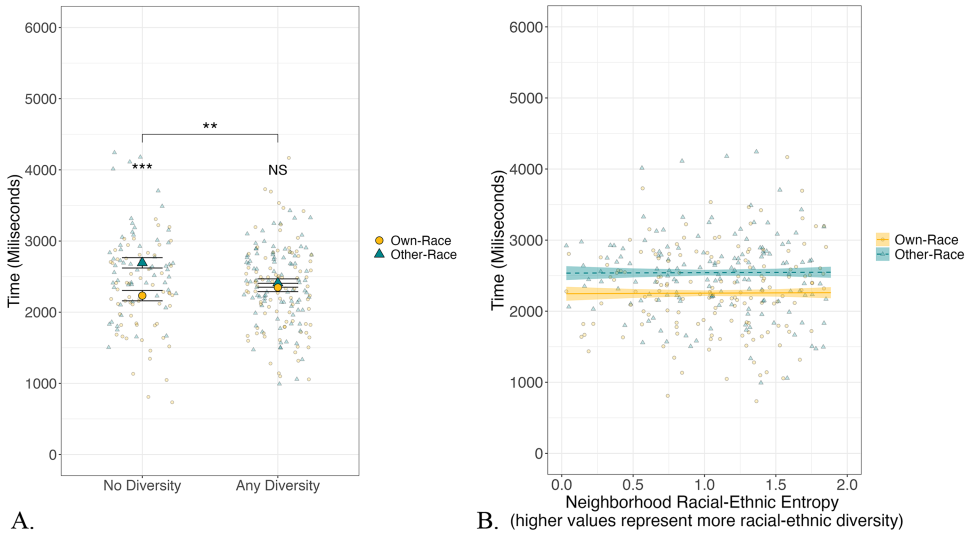
Third, since all multiracial infants were included in the group of infants with exposure to diversity in our analyses probing whether exposure to any racial–ethnic diversity in infants' social network moderates attention to own-race and other-race face (reported above, see Figure 3A)—and thus represented 31% of infants with any diversity in their social network—we sought to replicate these analyses with monoracial infants only. It could be the case that the observed moderation of social network diversity was instead due to unique experiences of multiracial infants, rather than exposure to diversity in social networks in general. To address this, we reran this analysis with only monoracial infants ($n = 119$). We replicate the effects reported above but find some moderation by age: monoracial infants with no diversity in their networks still look longer at other- than own-race faces (similar to Figure 3A) and monoracial infants with any diversity in their networks look similarly long at other-race and own-race faces, but this pattern was most clear for infants in the middle of our age range (e.g., 5- to 10-month-olds; see Section 7A in the online supplemental materials).

Discussion

Past work examining infants' attention to faces of different races has largely focused on populations of infants with little to no exposure to racial–ethnic diversity; whereas this work has been foundational for our understanding of how these processes develop in homogeneous environments, how these processes operate in more diverse environments has remained unclear, especially since the studies that have measured exposure to diversity have operationalized such exposure in an assortment of ways. In the present study, we aimed to expand our understanding of how infants attend to different-race faces across the first year of life and illuminate how this tendency relates to the racial–ethnic diversity of infants' social networks and neighborhoods. Overall, infants in our study looked longer at other-race than own-race faces—a pattern that was moderated their exposure to racial–ethnic diversity in their social network but was not moderated by age, as prior research has suggested (though see Sections 3B and 7A in the online supplemental materials—analyses using a different measure of social network diversity and with only monoracial infants suggested some variation across age).

Figure 3

Infants Visual Attention to Own-Race and Other-Race Faces by Social Network and Neighborhood Diversity



Note. Panel A depicts infants' attention to own-race and other-race faces as a function of exposure to diversity in their social networks (dichotomized as no diversity and any diversity); large dots are estimated means, error bars are standard errors, and small dots are horizontally jittered data points averaged at the participant level. In other words, these points represent the average amount of time an infant spent looking at own-race and other-race faces: for infants with no diversity present in their social network, there was a 0.35 *SD* gap in how long they looked at other-race versus own-race faces, whereas there was no gap for infants with any diversity in their social network. Panel B depicts infants' attention to own-race and other-race faces as a function of exposure to diversity in their neighborhoods. Lines are predicted effects, ribbons are standard errors, and small dots are data points averaged at the participant level. Neighborhood diversity did not relate to infants' looking to other- versus own-race races. See the online article for the color version of this figure.

In the present sample, infants with no diversity in their social network (i.e., those who only interacted with people of one race)—regardless of age—looked longer at other-race than own-race faces, whereas infants in more diverse social networks (i.e., those who interacted with people of two or more races) did not. This finding is conceptually consistent with Bar-Haim et al. (2006) to the extent that the patterns of infant-looking behavior were moderated by the racial demographics of the people who infants interacted with on a regular basis. However, the specific pattern of differential looking among infants with no diversity in their social network contrasts with prior work conducted with infants growing up in racially–ethnically homogeneous environments. That is, while previous studies found that 3-month-olds in these environments look longer at own-race than other-race faces (Bar-Haim et al., 2006; Fassbender et al., 2016; Kelly et al., 2005, 2007; Liu et al., 2015) and shift to looking longer at other-race than own-race faces at 9-months (Fassbender et al., 2016; Liu et al., 2015), we found that infants (3- to 14-months-old) looked longer at other-race than own-race faces regardless of age—a pattern similar to past research with infants from another racially heterogeneous society (Singapore; Singh et al., 2022; cf. Montoya et al., 2017).

Before exploring potential reasons for the discrepancy between infants' looking patterns in much of prior work and how infants behaved in the present study, it is important to keep in mind what visual attention can and cannot tell us. As reviewed in the introduction, it is not clear which precise mechanisms cause infants to attend differentially to different-race faces. In prior looking time paradigms, infants sometimes look longer at familiar stimuli (as 3-month-old infants did in Bar-Haim et al., 2006; Fassbender et al., 2016; Kelly et al., 2005, 2007; Liu et al., 2015), sometimes at novel stimuli (as those in less diverse social networks did here; see also Singh et al., 2022; and 9-month-old infants in Fassbender et al., 2016; Liu et al., 2015), and sometimes at neither (as those in more diverse social networks did here; see also Bar-Haim et al., 2006; Montoya et al., 2017). Thus, while both past work and the present study suggest that whether race is a variable that makes a face more or less novel to an infant depends on the degree of racial diversity in their social network, there is an open question of what determines which faces infants attend to when they do not attend equally—specifically, whether infants look longer at more novel or familiar faces.

One possible explanation for why even the younger infants from less diverse environments in our study looked longer at other-race faces while 3-month-old infants in past studies looked longer at own-race faces might have to do with the degree of novelty of the other-race faces. In prior work (Bar-Haim et al., 2006; Fassbender et al., 2016; Kelly et al., 2005, 2007; Liu et al., 2015), infants in homogeneous environments had little-to-no exposure to other-race faces at all (due to the high degree of homogeneity in their communities, Kelly et al., 2007; or exclusion criteria that allowed inclusion only of infants whose parents reported they had never seen an other-race face, Fassbender et al., 2016). Indeed, infants in these previous studies were recruited from countries (e.g., China, Ethiopia, Germany, Israel, the United Kingdom) that have considerably less racial–ethnic diversity than the United States, where the current research took place. Thus, the other-race faces in previous studies were completely novel, which could have resulted in a degree of novelty that infants (particularly younger infants) in those studies were not prepared to process, leading them to look longer at own-race faces (a similar response observed in studies of other areas of infant perception; e.g., Damon et al., 2021; Kidd et al., 2012). Although infants from the present study who lived in less diverse environments did not have people from different racial or ethnic backgrounds in their immediate social network, the majority lived in neighborhoods with at least some level of racial–ethnic diversity—their neighborhoods consisted of, on average, 31% other-race people—and thus could have been exposed to people of other racial–ethnic backgrounds more passively in daily life (as well as via books, media, and so on). From this perspective, although the other-race faces were more novel to these infants than infants in our study with more diverse social networks, they were perhaps less novel than they were for infants in prior work (who in some cases had never seen an other-race face). This possibility is also supported by the finding that 3-month-old infants in Singapore, another more racially diverse country, also look longer at other-race than own-race faces (Singh et al., 2022). Thus, perhaps infants look longer at other-race faces (e.g., because they are interesting or just take longer to process than more familiar faces) when they experience them as a little more novel than same-race faces but not as completely new (i.e., as in the case where an other-race face has never been seen by an infant at all).

Another potential explanation for why younger infants in our study looked longer at novel rather than familiar faces could have to do with the testing setting. In contrast to all other paradigms testing similar questions to date, infants in the present study participated from home rather than from a research lab. Thus, infants (especially younger infants) may have been more comfortable visually exploring novel stimuli at home compared to when in an unfamiliar lab setting. A related possibility concerns the timing of this research, which took place during the COVID-19 pandemic. It is possible that the social isolation experienced as part of the pandemic changed how infants attend to familiar and novel stimuli (e.g., Yates et al., 2023), although future research will be needed to further bear upon this possibility.

Although infants in the present study looked longer at other-race than own-race faces across age (rather than showing a shift from own-race to other-race, as in prior research with majority-race infants growing up in racially homogenous environments), our findings are consistent with prior work in illustrating how experiences with diversity moderate these patterns. In particular, infants with more diverse social networks (i.e., infants who interreacted with more than one racial group on a regular basis) looked equally to own-race and other-race faces, mirroring the patterns of Ethiopian infants raised in Israel (who similarly had more exposure to racial diversity relative to the other groups tested; Bar-Haim et al., 2006). Thus, these data lend support to the theory that visual attention to own-race and other-race faces varies as a function of the relative familiarity of own-race faces compared to the relative novelty of other-race faces in infants' social environment. That is, if infants are exposed to more than one racial–ethnic group, the familiarity-novelty difference between two different-race faces is very small (and so visual attention is equated), but if infants are exposed to only one racial–ethnic group, the familiarity-novelty difference is large (and so visual attention is biased). In future work, it would be helpful to identify more precisely how experiences with racial diversity in daily life shape infants' perceptions of novelty. For example, does exposure to more than one race in daily life lead infants to generally view variation in skin tone as less novel (e.g., such that infants with both Black and White people in their network are also less likely to view Asian and Hispanic faces as novel)? Or are these effects more specific to those racial–ethnic groups to which infants are exposed (e.g., such that infants with exposure to Black and White people in their network still see Asian or Hispanic faces as novel)? While we intended to test this with our data, there were very few infants who had exposure to some groups but not others (e.g., only four infants had Black people but not White people in their social networks) which dramatically limited our ability to explore this question.

Given the influence of racial–ethnic diversity on infant looking patterns, it is also important to highlight that the present sample included a sizeable number of multiracial infants ($n = 41$; 20%). As a group, these infants looked longer at other-race than own-race faces (see Section 3A in the online supplemental materials), consistent with the overall pattern in our sample, but potentially contrary to the idea that exposure to more than one race attenuates attention to own-race and other-race faces. One potential explanation for these descriptive patterns could be that multiracial infants are unique in which experiences are required to attenuate attentional biases. For example, it is possible that exposure to other-race people (rather than simply exposure to more than one racial or ethnic group, of which they are both a part) is required to attenuate attention to own-race and other-race faces. This possibility is broadly consistent with prior work suggesting that multiracial infants scan own-race and other-race faces differently than do monoracial infants (Gaither et al., 2012); however, we are unable to test this possibility here because very few multiracial infants (14%) had any other-race people represented in their social networks. Future work is required to fully flesh out how experience with people of different racial–ethnic backgrounds—including those shared and not shared with infants—relates to attention to own-race and other-race faces (see Section 3A in the online supplemental materials for preliminary findings).

In comparison to our sizeable sample of multiracial infants, we had smaller samples of monoracial–ethnic infants of color ($N_{\text{Asian}} = 15$; $N_{\text{Black}} = 9$; $N_{\text{Hispanic}} = 8$). While monoracial Asian infants looked longer at other-race than own-race faces (as did the full sample, see Section 3A in the online supplemental materials), the patterns for monoracial Black and Hispanic infants did not reach significance. Given how small both samples were (ns < 10), we hesitate to draw any conclusions from the lack of significance for these groups. Further work is required to understand how these numerical minority groups differentially attend to own-race and other-race faces.

Unlike social network diversity, neighborhood diversity did not moderate infants' looking patterns—a finding consistent with Singarajah et al. (2017), who similarly found no effect of infants' neighborhoods on their looking to faces of different races. Thus, it appears that, although infants show sensitivity to the demographic composition of their neighborhoods on some measures (e.g., Ellis et al., 2017; Hwang et al., 2021), close social contact with individuals of multiple racial–ethnic identities may be more important than neighborhood diversity for reducing an attentional bias to own-race or other-race faces in infancy. It is also possible, however, that infants in the present sample had less contact with people in their neighborhood than they typically would due to the fact that the study was administered during the pandemic (before infants and young children could be vaccinated) and that neighborhood diversity would relate to infants' looking behavior in other contexts. In future work, it would be helpful to additionally measure infants' interactions in their neighborhoods (e.g., time spent in parks, interactions with strangers) to assess whether the effect of neighborhood characteristics varies for infants with different experiences in their neighborhoods—a level of detail we were unable to capture with just the measure of neighborhood diversity provided by the U.S. census.

Nonetheless, the role of network diversity revealed in our study has important theoretical implications. The perceptual-to-social linkage hypothesis (Lee et al., 2017) proposes that implicit racial attitudes can be tied to differential exposure to faces in infancy and that the early emerging visual bias for own-race faces over other-race faces for infants growing up in homogenous environments (e.g., Bar-Haim et al., 2006; Fassbender et al., 2016; Kelly et al., 2005, 2007; Liu et al., 2015) is one of the first steps on this linkage. Consistent with this account, we found differential looking to own-race and other-race faces only among infants in racially–ethnically homogeneous social networks. Importantly, however, we found longer looking to other-race than own-race faces among these infants. This could mean that differential looking to own-race and other-race faces in infancy is a precursor to the development of racial biases, rather than just greater attention to own-race faces. Thus, in future work we aim to test directly whether differentiated looking in infancy relates to the development of racial bias in children (i.e., via a prospective longitudinal design), as well as the extent to which the direction of infants' biased visual attention matters for these processes or not.

In conclusion, our findings suggest that infants' visual attention to own-race versus other-race faces throughout the first year of life is attenuated when infants are exposed to racial–ethnic diversity in their social network.

Constraints on Generality

Our findings provide evidence for the theory that infants' visual attention to own-race and other-race faces is moderated by exposure to other-race people in their networks—that is, that infants' greater visual attention to own-race or other-race faces is due to a perceived discrepancy in the familiarity versus novelty of the two kinds of faces that is informed by their everyday exposure to different faces. All infants in this study live in the United States, a relatively racially–ethnically heterogeneous environment; thus, it remains an open question as to whether infants in more homogenous environments would also show greater visual attention to other-race faces in this particular paradigm (e.g., due to unique features of our study, such as the unmoderated remote platform) or rather show the developmental trajectory that has been observed in past work. Further, while we recruited infants from all racial–ethnic backgrounds, our resulting samples of monoracial–ethnic Asian, Black, and Hispanic groups were still small ($ns < 14$) and therefore limit our ability to extend the general patterns found in our total sample to all racial–ethnic groups represented in this research. Additionally, data collection occurred during the COVID-19 pandemic, prior to vaccinations for infants and children, and thus at a time where more people were using virtual platforms like Zoom to connect rather than in person interactions. Therefore, it is likely that infants were not as embedded in their broader community as they would be during non-pandemic times, which could make our measure of neighborhood diversity a less reliable proxy for capturing neighborhood-level exposure to diversity. Relatedly, because of the COVID-19 pandemic, infants in this study could have had more experience with visual stimuli displayed on computers than infants in studies conducted prior to the pandemic, leading to greater attention and easier processing of the procedure than might otherwise be the case. Finally, our face stimuli were all rated as prototypical of their racial or ethnic category (as judged by adult raters); however, it is plausible that infants' looking to less prototypical faces or racially or ethnically ambiguous faces would not show the same susceptibility to exposure. We have no other reasons to believe that the results depend on other characteristics of the participants, materials, or context.

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