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Older but not younger infants associate own-race faces with happy music and other-race faces with sad music

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Abstract
We used a novel intermodal association task to examine whether infants associate own- and other-race faces with music of different emotional valences. Three- to 9-month-olds saw a series of neutral own- or other-race faces paired with happy or sad musical excerpts. Three- to 6-month-olds did not show any specific association between face race and music. At 9 months, however, infants looked longer at own-race faces paired with happy music than at own-race faces paired with sad music. Nine-month-olds also looked longer at other-race faces paired with sad music than at other-race faces paired with happy music. These results indicate that infants with nearly exclusive own-race face experience develop associations between face race and music emotional valence in the first year of life. The potential implications of such associations for developing racial biases in early childhood are discussed.

RESEARCH HIGHLIGHTS

- Three- to six-month-olds did not show association between face race and music emotional valence.
- Nine-month-olds cross-modally associated own-race faces with happy musical excerpts.
- Nine-month-olds cross-modally associated other-race faces with sad musical excerpts.
- Early asymmetrical experience with own- versus other-race faces has downstream consequences.

1 | INTRODUCTION

Experience plays a crucial role in the development of face processing in infancy. With increased experience, infant face-processing ability not only improves but also becomes specialized to process the types of faces experienced most frequently (for a review, see Lee, Anzures, Quinn, Pascalis, & Slater, 2011). This specialization reflects the fact that infant face experience is typically asymmetrical. For example, infants encounter own-race faces significantly more than other-race faces (Liu, Xiao, Xiao et al., 2015; Rennels & Davis, 2008; Sugden, Mohamed-Ali, & Moulson, 2014).

Extensive studies have shown that owing to this own- versus other-race face experience asymmetry, infants process own- and other-race faces differently in the first year of life (Anzures et al., 2013). Whereas newborns show no visual preference for own- versus other-race faces, infants as young as 3 months look longer at own-race faces when they are paired with other-race faces (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly, Liu et al., 2007; Kelly et al., 2005; Liu, Xiao, Quinn et al., 2015). Moreover, whereas infants at 3 months initially recognize faces from various races equally well, by 9 months, they display superior recognition for own-race faces (Kelly et al., 2009; Kelly, Quinn, et al., 2007). In addition, although younger infants sort faces from different races into distinctive race categories, 9-month-olds group own-race faces into one category and multiple other-race face classes into another category (Quinn, Lee, Pascalis, & Tanaka, 2016). Furthermore, with increased age, infants exhibit specialized eye-movement patterns for own-race, but not for other-race, faces (Liu et al., 2011; Wheeler et al., 2011). These differential processing patterns for own- versus other-race faces reflect emergent expertise in the perceptual processing of own-race faces by infants as a result of asymmetrical exposure to own- versus other-race faces (Anzures et al., 2013; Lee et al., 2011).

Despite the substantial evidence regarding the effect of asymmetrical experience on the development of own- versus other-race face recognition and category formation by infants, it is entirely unknown whether the asymmetrical face race experience has any other downstream consequences. Recent studies have shown that preschoolers by 3 years of age not only recognize own-race faces better, but also are biased to associate own-race faces with positive emotional valence and other-race faces with negative emotional valence (e.g. Dunham, Chen, & Banaji, 2013; Qian et al., 2016; Xiao et al., 2015; for reviews, see Dunham, Baron, & Banaji, 2008; Lee, Quinn, & Heyman, in press). However, it is entirely unclear whether such biases already exist in infancy, and more specifically whether infants, like children, also associate own-race faces with positive valence and other-race faces with negative valence. The present study aimed to bridge this important gap in the literature.

It is reasonable to expect that infants may associate own-race faces with positive valence, given that much of infant own-race face experience is acquired through direct interaction with own-race adults who typically convey positive emotional signals. These positive emotional signals are commonly carried through positive facial expressions (Malatesta & Haviland, 1982), infant-directed speech (Kim & Johnson, 2014; Trainor, Austin, & Desjardins, 2000), and haptic interaction (Hertenstein & Campos, 2001; Hertenstein, Holmes, McCullough, & Keltner, 2009). Owing to the co-occurrence of positive emotional signals and own-race faces, infants may learn to associate own-race individuals with positive valence. Although no direct evidence supports this possibility, existing studies have shown that familiarity plays an important role in the associations infants make between faces and positive valence. Specifically, infants tend to associate familiar faces with positive emotional signals. For example, they associate happy facial expressions with happy voices when face and voice belong to their mother, but not when they are from strangers (Kahana-Kalman & Walker-Andrews, 2001; Montague & Walker-Andrews, 2002). Thus, given the fact that own-race faces are relatively more familiar than other-race faces, infants might also associate novel own-race faces with positive valence. The present study directly tested this 'own race is positive' hypothesis regarding own-race faces.

In contrast, no evidence exists regarding whether infants associate other-race faces with negative valence. Infants may associate negative emotional valence with other-race faces because infants develop stranger anxiety towards unfamiliar own-race individuals, with the anxiety becoming stronger with age (e.g. Bigelow, MacLean, Wood, & Smith, 1990; Bronson, 1972). For example, 9-month-olds show accelerating heart rate when seeing a stranger of their own race, which is not observed in infants at 5 months. This finding suggests that infants between 5 and 9 months develop fearful responses towards unfamiliar individuals (Campos, Emde, Gaensbauer, & Henderson, 1975). Given that other-race faces are perceptually different from faces of own-race strangers in terms of salient facial information (Anzures, Quinn, Pascalis, Slater, & Lee, 2010), infants may show even stronger 'stranger anxiety' towards other-race faces. Thus, it is plausible that, with increased age, infants will come to associate negative valence with other-race faces. According to this hypothesis, infants may treat other-race faces fundamentally differently from novel own-race faces by associating other-race faces with negative emotional signals. The present study also directly tested this 'other race is negative' hypothesis regarding other-race faces.

In order to test the above two hypotheses concurrently regarding own- and other-race faces, we developed a novel intermodal association paradigm. A typical intermodal association task involves the presentation of stimuli in two modalities sequentially or simultaneously. The association is assessed by examining the different responses between 'congruent' and 'incongruent' trials. On congruent trials, the stimuli in the two modalities share a certain commonality, such as happy expressive faces paired with happy voices. By contrast, on incongruent trials, the characteristics in one modality are not consistent with the characteristics in the other modality, such as happy expressive faces paired with sad voices. Existing studies using such intermodal association paradigms have consistently found that infants associate audio and visual signals on the basis of speech content (Kuhl & Meltzoff, 1984; Patterson & Werker, 2002, 2003; Pons, Lewkowicz, Soto-Faraco, & Sebastián-Gallés, 2009), emotional valence (Hietanen, Leppänen, Illi, & Surakka, 2004; Soken & Pick, 1992), gender information (Hillairet de Boisferon et al., 2015; Patterson & Werker, 2002), age characteristics (Bahrick, Netto, & Hernandez-Reif, 1998), and face race with native or non-native speech (Uttley et al., 2013). However, no such study has examined the association between face race and emotional valence. In the current study, we paired unfamiliar own- or other-race neutral faces sequentially with positive or negative auditory signals in order to examine the associations infants make between own- versus other-race faces and positive versus negative valence. The positive versus negative auditory signals were delivered by presenting happy versus sad musical excerpts.

Our paradigm capitalizes on the ability that infants as young as 3 months have to discriminate between faces from different races (Kelly et al., 2005, 2009; Kelly, Liu et al., 2007; Kelly, Quinn et al., 2007; Liu, Xiao, Xiao et al., 2015). Furthermore, convergent evidence suggests that adults and children can reliably identify the emotional valence of happy and sad musical excerpts (Adachi, Trehub, & Abe, 2004; Balkwill & Thompson, 1999; Balkwill, Thompson, & Matsunaga, 2004; Dalla Bella, Peretz, Rousseau, & Gosselin, 2001; Juslin & Laukka, 2003; Kratus, 1993; Rock, Trainor, & Addison, 1999; Schmidt, Trainor, & Santesso, 2003; Trainor & Trehub, 1992; for a review, see Trainor & Corrigall, 2010). More relevant to the present study, studies have shown that infants between 5 and 9 months are also capable of discriminating happy and sad musical excerpts (Flom, Gentile, & Pick, 2008; Flom & Pick, 2012). They can additionally match happy music with happy facial expressions (Gentile, 1998; Nawrot, 2003). These

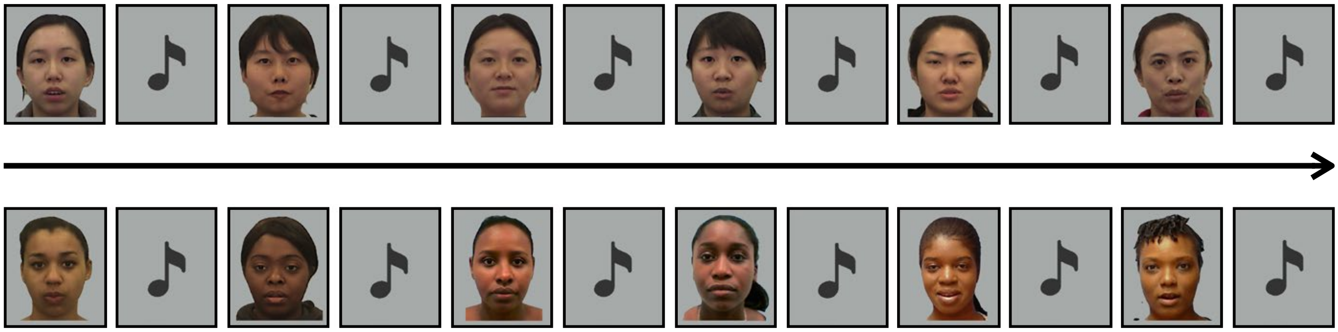

FIGURE 1 The stimulus sequences in the two sets of conditions. In the own-race conditions (the top row), Asian face videos were sequentially paired with happy musical excerpts in the congruent condition, and with sad musical excerpts in the incongruent condition. In the other-race conditions (the lower row), African face videos were sequentially paired with sad musical excerpts in the congruent condition, and with happy musical excerpts in the incongruent condition. When the musical excerpts were played, a crosshair appeared in the middle of the screen

studies together suggest that infants can distinguish musical excerpts in terms of positive versus negative valence.

Using a between-subjects design, we presented four groups of Chinese 3- to 9-month-olds with videos of either congruent or incongruent trials. On own-race congruent trials, infants saw a series of videos of own-race faces with neutral expressions that were sequentially paired with a series of happy musical excerpts. On other-race congruent trials, infants saw a series of videos of other-race faces with neutral expressions that were sequentially paired with a series of sad musical excerpts (Figure 1). On incongruent trials, the pairings between the race of the faces and the valence of the musical excerpts were reversed. We examined how long infants would maintain their attention to the face–music pairings on the congruent versus incongruent trials. Because repeated presentation of the same stimulus leads infants to habituate and thus rapidly decrease attention to the stimulus, we presented novel faces and novel musical excerpts sequentially that were never repeated. Presenting stimuli in different modalities is known to sustain infant attention and to prevent rapid habituation (Althaus & Mareschal, 2014; Reynolds, Zhang, & Guy, 2013).

We hypothesized that if the above two hypotheses regarding own- and other-race faces are correct, infants should associate positive music with own-race faces and negative music with other-race faces. Consequently, infants should show greater attention towards the face–music stimuli on the congruent trials than on the incongruent trials. These predictions are based on the findings that cross-domain congruency promotes infant exploration of visual and auditory stimuli, thereby making infants less likely to habituate and leading to longer maintenance of looking time (Bahrick & Lickliter, 2000; Grossmann, Striano, & Friederici, 2006; Kubicek et al., 2014). Moreover, because we hypothesized that the own–positive and other–negative associations reflect asymmetric face race experience, and given that perceptual specialization for own- relative to other-race faces increases between 3 and 9 months (e.g. Kelly, Quinn et al., 2007; Kelly et al. 2009; Quinn et al., 2016), we predicted that the associations would become increasingly evident across the age range tested.

2 | METHOD

2.1 | Participants

A total of 193 full-term Chinese infants from 3 to 9 months of age participated in the current experiment after their caregivers gave informed consent. They were recruited from a community hospital in a large metropolitan city in China where the infants came to receive wellness checkups. Forty-nine infants participated in the own-race + happy-music condition (M = 189.43 days, SD = 66.82 days), 49 infants participated in the other-race + sad-music condition (M = 192.57 days, SD = 65.93 days), 50 infants participated in the own-race + sad-music condition (M = 188.74 days, SD = 67.50 days), and 45 infants participated in the other-race + happy-music condition (M = 186.13 days, SD = 66.55 days). Based on caregiver report, infants had not had any prior direct contact with individuals from other races. The city from which the infants were recruited is racially homogenous, with 99.99% of the population being Han Chinese. None of the infants had previously seen the face stimuli used in the current study.

We also surveyed infant exposure to happy and sad music in the parents of 67 infants out of the whole sample. According to parent reports, 82% (N = 55) of the infants had frequently experienced happy music, which was derived from toys, songs and TV programs, whereas 18% (N = 12) of the infants had occasionally experienced sad music from such occurrences as watching a sad TV program or attending a funeral. A chi-squared goodness-of-fit test showed that more infants had been exposed to happy music than to sad music ($\chi^2 = 15.38$, $p < .001$). None of the infants had been previously exposed to the musical stimuli used in the current study.

Twenty-nine additional infants participated, but were excluded from the data analysis because of failure to complete the procedure owing to fussiness ($n = 20$: $n_{own\text{-}happy} = 4$, $n_{own\text{-}sad} = 2$, $n_{other\text{-}happy} = 9$, $n_{other\text{-}sad} = 5$), calibration failure ($n = 3$), extremely short total looking time across the session (i.e. <1 s for each trial, $n = 2$), parent interference ($n = 2$), or premature birth ($n = 2$). Experiments were approved by the Research Ethics Boards of the University of Toronto and by the

Institutional Ethics Board of Zhejiang Sci-Tech University. Informed consent was obtained from the caregivers of the infants.

2.2 | Stimuli

Videos of six Asian and six African females with frontal views were used as face stimuli (Age: 21 to 28 years). Each video depicted a face counting numbers silently with a neutral facial expression. The reason why we presented moving face videos, instead of static face images, was because prior studies have consistently shown that infants tend to perceive neutral static faces as emotionally negative (i.e. the still-face effect, Adamson & Frick, 2003; Toda & Fogel, 1993). The videos were edited to ensure that faces were similar in size, and placed on a light color background (Figure 1). In addition, we ensured that the models from both races spoke and moved at the same tempo, which was achieved by asking the models to count the numbers at a steady pace. We then used video editing software (Adobe Premiere Pro) to adjust the speed of each video, thereby ensuring that each model moved their mouth 10 times (counted 10 numbers) within 10 s. Thus, each face moved at the same tempo. We measured the pace of the facial movements of the models and found that the own- and other-race adults did not differ in their facial movement tempo ($M_{own} = 10$, $SD_{own} = 0$, $M_{other} = 10$, $SD_{other} = 0$). Each face video was played for 10 s.

We also assessed the attractiveness and emotional valence of the face stimuli by raters who were blind to the purpose of the study. Twelve Asian female adults (22 to 28 years old) rated the attractiveness of the face stimuli with a 9-point Likert scale (1: very unattractive, 5: neutral, and 9: very attractive). The reason we included only females for the facial attractiveness rating is because the current study used only female faces and cross-gender attractiveness judgments are less reliable than same-gender attractiveness judgments (Rhodes, Hickford, & Jeffery, 2000; Sofer, Dotsch, Wigboldus, & Todorov, 2015). A paired-sample *t*-test was used to examine whether the mean attractiveness rating for own-race faces differed from that for other-race faces. The results showed that the attractiveness of the own-race Asian faces ($M = 3.47$, $SD = 1.47$) was not significantly different from the attractiveness of the other-race African faces ($M = 3.63$, $SD = 1.38$), $t[11] = 1.04$, $p = .323$. Twelve additional Asian adults (23 to 26 years old, 6 females and 6 males) rated the emotional valence of the face stimuli. A 7-point Likert scale was used (1: very negative, 4: neutral, and 7: very positive). Neither the Asian ($M = 4.05$, $SD = 0.40$) nor the African ($M = 4.14$, $SD = 0.50$) faces differed significantly from neutral (one-sample *t*-test: $ps > .068$). Moreover, the Asian and African faces did not differ from each other in valence (paired-sample *t*-test: $t[11] = 0.92$, $p = .378$).

Each musical excerpt was a piano piece, and, like each face video, also lasted 10 s. Six of the excerpts conveyed positive (happy) emotion and another six conveyed negative (sad) emotion. We matched each musical excerpt to the same perceived loudness (−23 dB). Since the time of Euler, emotion in music has been shown mathematically and empirically to be conveyed primarily by scale and tempo (Gabrielsson & Lindström, 2001; Pesic, 2014). Thus, we specifically chose happy and sad musical excerpts that differed in these two key musical properties so as to ensure that the excerpts clearly presented happy and sad emotional valences. The positive musical excerpts were thus in the major scale with fast tempo (184.47 to 275.23 bpm). The negative musical excerpts were in the minor scale with slow tempo (48.30 to 146.25 bpm). In order to examine whether the musical excerpts indeed conveyed happy versus sad emotional valence, 12 Asian adult raters (25 to 33 years old, seven females and five males), who had not received formal musical training, rated the emotional valence of the musical excerpts. The raters were blind to the purpose of the study. Each musical excerpt was rated according to a 7-point Likert scale (1: very sad, 4: neutral, and 7: very happy). The happy musical excerpts were rated as significantly happier than neutral ($M = 6.29$, $SD = 0.36$, one-sample *t*-test: $t[11] = 21.85$, $p < .001$), and the sad musical excerpts were rated as significantly more sad than neutral ($M = 2.45$, $SD = 0.59$, one-sample *t*-test: $t[11] = -9.10$, $p < .001$).

2.3 | Procedure

Each infant was randomly assigned to one of the four face-race + music conditions. In the own-race + happy-music condition (own-happy), infants watched six Asian face videos sequentially paired with six musical excerpts in the following manner. First, a face video was shown for 10 s, followed by a happy musical excerpt for 10 s, and then a new video with a new face appeared, followed by a new happy musical excerpt, and so on until all six face videos and six musical excerpts had been played. A crosshair appeared on the screen when each musical excerpt was played. Each participant thus saw six Asian faces interleaved with six positive musical excerpts. The sequence of the six specific face videos with the six specific musical excerpts was randomized across participants. The other-race + sad-music (other-sad), own-race + sad-music (own-sad), and other-race + happy music (other-happy) conditions were procedurally the same as the own-happy condition, except for the face-music composition. African faces and sad musical excerpts were used in the other-sad condition. African faces and happy musical excerpts were used in the other-happy condition. Asian faces and sad musical excerpts were used in the own-sad condition. Following the convention of the existing literature, we refer to the own-happy and other-sad conditions as the congruent conditions, and the other two conditions as the incongruent ones (see Figure 1 for a schematic depiction of the procedure).

Infant eye movements were recorded by a Tobii 1750 eye tracker (50-Hz sampling rate). Each testing session started with an infant-controlled calibration program to ensure eye tracking precision and accuracy. During calibration, a cartoon figure was presented on the screen. If infants successfully fixated on the cartoon figure for 1 s, it would move to another position. The calibration was achieved when infants successfully fixated at five locations (four corners and the center). Raw eye-tracking data were first filtered to generate the fixation data. A fixation was defined as at least 100 ms of continuous looking with a spatial dispersion of no more than 30 pixels (Liu et al., 2011).

3 | RESULTS

We first examined looking time on the first face video in all four conditions because at that point the musical excerpts with different emotional valences had not been played. We conducted a multi-variable linear

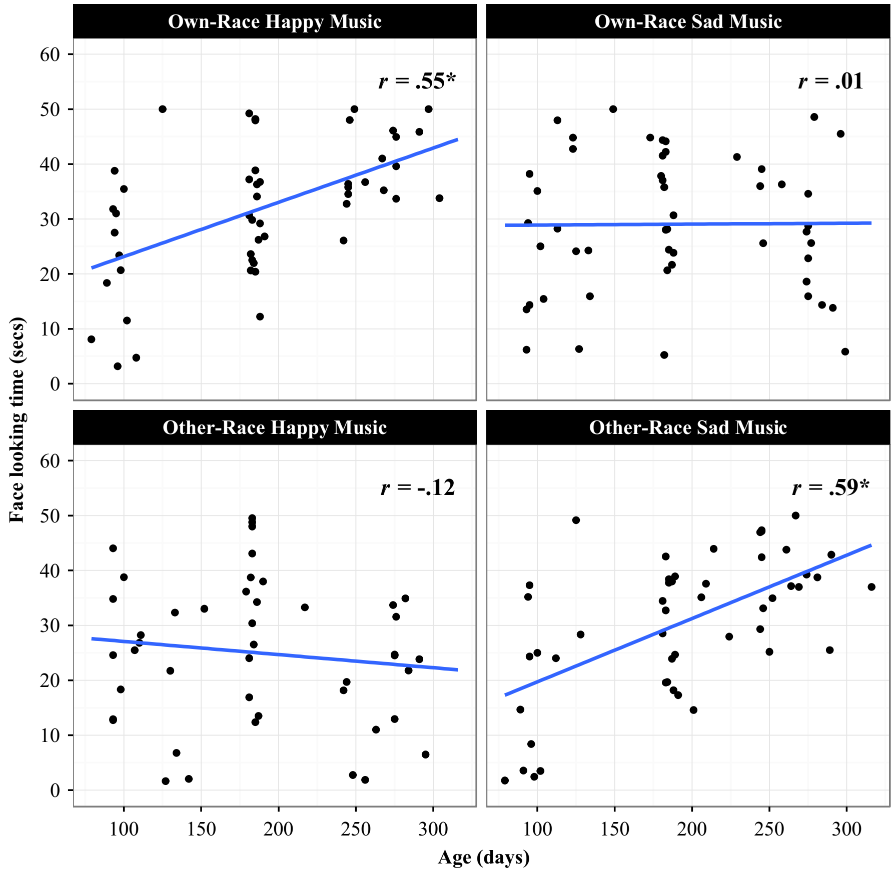

FIGURE 2 Each infant's total face looking time as a function of age in the four conditions. The blue line represents the linear regression line between face looking time and participant age. Each panel presents the looking time and age correlation for a given experimental condition. The value in the upper-right corner indicates the Pearson correlation coefficient for each condition. The asterisks indicate that the correlation was significant ($p < .05$)

regression on the first face looking time as the predicted variable, with age in days, face race, and their interactions as the predictors. The results revealed only a significant main effect of age ($F[1, 186] = 8.52$, $p = .004$, $\eta^2_p = .04$): as age increased, looking time on the first face also increased regardless of face race. However, no significant effects were observed for face race or any of the interaction terms (*ps* > .460). Infants spent a similar amount of time looking at own-race faces ($M = 7.18$ s, $SD = 2.86$ s) and other-race faces ($M = 6.90$ s, $SD = 2.55$ s). These results indicate that own- and other-race faces alone were insufficient to elicit a difference in looking time. It should be noted that three infants did not look at the first face but looked at the rest of the faces. We excluded these infants in the statistical analyses for the first face looking time, but included them in the subsequent analyses, so the mismatched *df* values for those analyses reflected this situation.

The analyses to follow emphasize two aspects of the association between face race and music emotional valence: (1) developmental change at the level of individual performance, using age as a continuous variable, and (2) emergence of an association in developmental time at the level of group performance, in which infant looking is compared across three age groups: 3, 6, and 9 months of age.

3.1 | Developmental change in the association of face race and music emotional valence

Each infant's looking times to the subsequent five faces were summed to provide an index of their total looking time to the five faces after happy or sad musical excerpts were played. We conducted a multivariable linear regression similar to the one described above. Total looking time was the predicted variable, with age in days, face race, musical emotion, and their interactions as the predictors. The results revealed a main effect of age ($F[1, 185] = 15.22$, $p < .001$, $\eta_p^2 = .08$), indicating an age-related increase in total face looking time. The results also revealed a significant race × emotion interaction ($F[1, 185] = 5.63$, $p = .019$, $\eta_p^2 = .03$). More importantly, there was a significant race × emotion × age interaction ($F[1, 185] = 21.56$, $p < .001$, $\eta_p^2 = .10$), showing that the relationship between age and face looking time was modulated by face race and emotion (Figure 2). This three-way interaction indicated that with increased age, infants had different face looking responses when the faces were paired with congruent musical excerpts versus incongruent musical excerpts. We did not observe any other significant main effects or interactions (*ps* > .109).

Given the significant three-way interaction, we used Pearson correlation analyses to examine the linear relationship between total face looking time and participant age in days in each condition. As shown in Figure 2, for the own-happy condition, the analysis revealed a significant positive correlation between own-race face looking time and age ($r = .55$, $p < .001$). Looking time of the infants for own-race faces increased with age if the faces were presented with happy musical excerpts. In contrast, other-race face looking time of the infants increased with age when the faces were presented with sad musical excerpts ($r = .59$, $p < .001$). Thus, with increased age, infants became increasingly attentive to congruent face-music sequences: own-race faces presented

TABLE 1 Number of participants and mean age in days for each age group and condition

	3 months (79–152 days)			6 months (173–217 days)			9 months (242–297 days)		
Condition	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
Own-race happy music	13	97.69	10.65	19	184.79	2.82	17	264.76	20.23
Own-race sad music	17	112.71	17.42	16	182.81	3.60	17	270.35	19.55
Other-race happy music	16	113.06	20.22	15	185.80	9.03	14	270.00	16.92
Other-race sad music	13	100.31	13.86	19	192.11	12.49	17	263.65	20.89
Total	59	106.76	17.37	69	186.57	8.71	65	267.06	19.35

with happy music and other-race faces presented with sad music. We examined whether the correlation coefficient in the own-happy condition differed from that in the other-sad condition by using a Fisher *r*-to-*z* transformation. The results showed no significant difference between the two correlation coefficients ($z = 0.31$, two-tailed $p = .756$).

For the two incongruent conditions, we did not observe significant correlations between face looking time and age in the own-sad condition ($r = .01$, $p = .952$) or other-happy condition ($r = -.12$, $p = .428$), which were not different from each other ($z = 0.62$, $p = .535$). Thus, when the face–music compositions were incongruent, the face looking time of infants did not systematically change with increased age. Moreover, the correlation coefficient for the own-happy condition was significantly higher than that for the own-sad condition ($z = 2.92$, $p = .003$), and the correlation coefficient for the other-sad condition was significantly higher than that for the other-happy condition ($z = 3.75$, $p < .001$). These results suggest that, with increased age, infants increasingly associate own-race faces with happy music, and other-race faces with sad music.

3.2 | Emergence of the association of face race and music emotional valence in developmental time

The results just described showed developmental trends in face looking time as a function of the associations of face race and music emotional valence. We further explored the emergence of the associations by determining the age at which infants showed different patterns of looking time on the faces for the happy and sad music emotional valence conditions. We split participants into three age groups (i.e. 3-, 6-, and 9-month-old groups) according to the distribution of their age in days. Table 1 shows the number of participants in each age group for each of the four conditions.

We performed a series of independent sample *t*-tests to examine the effects of music emotional valence on the looking time for own- and other-race faces in each age group. As shown in Figure 3, infants at 9 months of age looked longer at own-race faces paired with happy music ($M = 39.44$ s) than at own-race faces paired with sad music ($M = 28.25$ s), $t(32) = 3.30$, $p = .002$. Nine-month-olds also looked longer at other-race faces paired with sad music ($M = 38.69$ s) than at other-race faces paired with happy music ($M = 19.14$ s), $t(29) = 5.91$, $p < .001$. By contrast, we did not find any effect of music emotional valence on face looking time in 3-month-olds (own-race faces: $t[28] = 0.71$, $p = .481$; other-race faces: $t[27] = 0.563$, $p = .578$) or 6-month-olds (own-race faces: $t[33] = 0.20$, $p = .846$; other-race faces: $t[32] = 0.73$, $p = .471$). These results suggest that infants at 3 and 6 months of age did not associate own-race faces with happy music or other-race faces with sad music. At 9 months, infants were significantly more inclined to associate own-race faces with happy music than with sad music, and other-race faces with sad music than with happy music.

4 | DISCUSSION

We used an intermodal association paradigm to investigate the development of association for own- and other-race neutral faces with happy versus sad music from 3 to 9 months of age. Specifically, we relied on infant looking time to test whether infants associate own- and other-race faces differentially with music of different emotional valences. Two major findings were obtained.

First, infants from 3 to 6 months of age did not show any differences in looking time to the own- versus other-race faces when they were paired with musical excerpts that conveyed happy or sad emotions, supporting a 'no association' hypothesis. This outcome indicates that infants initially did not associate face race with music emotional valence, suggesting that infants are not biologically predisposed to associate own- and other-race faces with music of differential emotional valence. The finding that infants from 3 to 6 months did not associate other-race faces with sad music differs from a prior result that infants at 6 months associated other-race faces with non-native speech (Uttley et al., 2013). The difference in outcomes might indicate that the association beween face race and language emerges earlier than that between face race and music emotional valence.

Our second major finding is that, unlike the younger infants, infants at 9 months looked longer at own-race faces paired with happy music, and at other-race faces paired with sad music. This age-related change cannot be explained by the stimulus characteristics of face or music alone because we used exactly the same faces and musical excerpts in the incongruent conditions. In the incongruent conditions, infant attention to the same faces did not change with increased age when the faces were presented with incongruent music (i.e. own-race faces paired with sad music, and other-race faces paired with happy music). This second major finding thus supports the hypothesis that older infants associate face race with music emotional valence: they

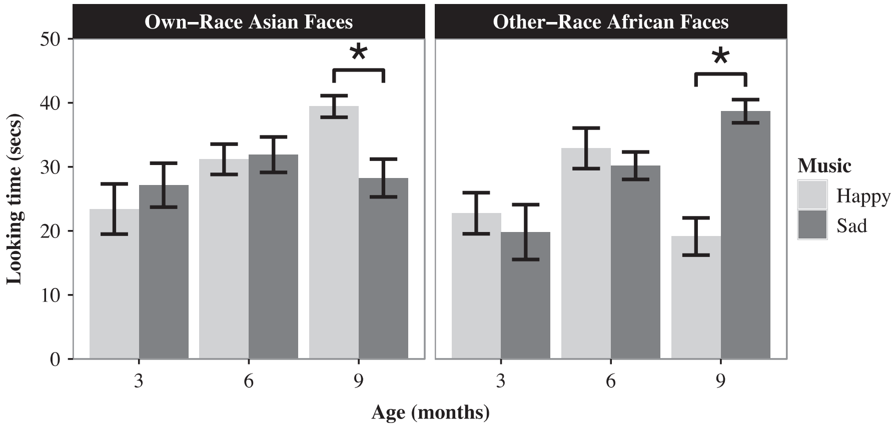

FIGURE 3 Means of total looking time on the own- and other-race faces paired with happy or sad music for each age group. The asterisks indicate a significant difference in face looking time when the faces were paired with happy versus sad music (independent sample *t*-test, $p < .05$). Each error bar represents a unit of standard error

associate own-race faces with happy music and other-race faces with sad music.

To our knowledge, the present study is the first to document the development of associations of own- and other-race faces with music of different emotional valences during the first year of life. This emerging association likely builds on the existing abilities of infants as young as 5 to 6 months of age to decode face race and music emotional valence information. As mentioned in the introduction, infants as young as 6 months can readily extract race-specific information from the faces they are viewing (Anzures et al., 2013; Quinn et al., 2016). The face stimuli used in the present study were chosen to capitalize on this early emerging ability in infants. Infant ability to process music emotional valence has been revealed with the use of musical excerpts differing in such important acoustic properties as tempo (fast vs. slow) and scale (major vs. minor). In particular, it is well established that music in a major scale with fast tempo universally conveys happy emotional valence, whereas music in a minor scale with slow tempo conveys sad emotional valence (Gabrielsson & Lindström, 2001; Pesic, 2014), with a strong neural basis (e.g. Mitterschiffthaler, Fu, Dalton, Andrew, & Williams, 2007). Evidence shows that, from as early as 5 months, infants are able to discriminate happy and sad musical excerpts (Flom et al., 2008; Flom & Pick, 2012). They also can match happy music with happy facial expressions (Gentile, 1998; Nawrot, 2003). The musical excerpts used in the present study thus took advantage of the ability of infants to decode music emotional valence. Overall, then, the infant findings suggest that infants as young as 5 to 6 months of age not only can decode face race information, but also can detect emotional valence in music. By relying on the existing abilities of infants to process face race and music emotional valence information, here we were able to reveal that 9-month-olds, but not younger infants, associated face race with music emotional valence.

The reason that infants associated own-race neutral faces with happy music may reflect the fact that infants primarily see own-race faces (Rennels & Davis, 2008; Sugden et al., 2014), which mostly pose positive expressions (Malatesta & Haviland, 1982) and deliver joyful infant-direct speech (Kim & Johnson, 2014; Trainor et al., 2000). In addition, the survey results about music exposure of the infants in our sample revealed that more were exposed to happy music than to sad music. As a result, they may develop a specific association to perceive own-race faces as emotionally positive entities, even if the faces remain expressively neutral.

We also found that 9-month-olds, but not 3- or 6-month-olds, associated neutral other-race faces with sad musical excerpts. Because the infants in the current study had no previous direct experience with other-race individuals, the emergence of the negative emotional association with other-race faces must not have arisen from direct negative experience with other-race individuals. One possible explanation is stranger anxiety. Extensive studies have shown that human infants display negative affective reactions towards own-race strangers in the first year of life (Bigelow et al., 1990; Feinman, 1980). For example, 9-month-old infants show wariness to strangers (Bronson, 1972), and this stranger anxiety develops with age within the first year of life (Campos et al., 1975). Given that other-race faces are more perceptually different than stranger own-race faces (relative to familiar own-race faces), infants may perceive the former as even more strange than the latter. As a result, infants may associate negative emotional valence with other-race faces.

Thus, the developmental differences in face race and musical valence association may reflect the asymmetrical experience of infants with both face race and musical valence. In other words, this biased association may be based on familiarity. Owing to their familiarity with own-race faces and happy music, infants develop a specific association to perceive own-race faces as emotionally positive entities, even if the faces remain expressively neutral. In the same vein, owing to their unfamiliarity with other-race faces and sad music, they associate other-race faces with sad music. This experience-based cross-modal association is consistent with a growing body of literature showing that infant social cognition is shaped by experience (Waxman, 2012, 2013). For example, older infants exhibit increased toy acceptance (Kinzler, Dupoux, & Spelke, 2007; Kinzler & Spelke, 2011), prosocial action (Cirelli, Einarson, & Trainor, 2014), and imitative behavior (Buttelmann, Zmyj, Daum, & Carpenter, 2013) towards individuals who share similar characteristics with the infant's own experience, such as speech accent and movement synchrony.

Alternative explanations for our findings should be entertained. First, one possibility is that infants simply match the tempo of the music with the speech tempo of the faces. However, as reported in the Method section, the way that the face videos were created ensured that there were no differences in the tempos of the own- and other-race face stimuli. Second, as infants are known to be more experienced with processing own-race faces, it is possible that they may process own-race faces faster than other-race faces. As a result, they match the more rapidly processed own-race faces to the faster tempo of happy music. However, even though it is well established that infants at 9 months of age discriminate own-race faces better than other-race faces, no evidence suggests that they process the former faster than the latter. For example, several studies have shown that infants habituate to own-race faces no faster than to other-race faces (e.g. Kelly, Quinn et al., 2007), and at least one study has reported the opposite effect whereby infants show more rapid habituation to other-race faces relative to own-race faces (Anzures et al., 2010). In addition, using ERP (event-related potential) methodology, Balas, Westerlund, Hung, and Nelson (2011) have shown that infants do not differ in their neural response latency in face-relevant ERP components (i.e. N290 and P400). The existing evidence thus suggests that infants do not have a speed-of-processing advantage for own-race faces. Similarly, existing studies have not revealed processing speed differences between happy and sad music in infants (Flom et al., 2008; Flom & Pick, 2012).

Although we have reasoned that experience (i.e. familiarity) underlies the development of the linkage between face race and music emotional valence, future studies need to ascertain exactly how familiarity engenders the linkage between face race and musical valence in infancy. One possibility is that infants simply associate whatever is visually familiar (or unfamiliar) with whatever is auditorially familiar (or unfamiliar) regardless of the nature of the visual and auditory stimuli. A second possibility is that infants may associate own-race faces with happy music because both types of familiar stimuli evoke positive responses, and associate other-race faces with sad music because both types of unfamiliar stimuli evoke negative responses. To examine these possibilities, following from the work of Heron-Delaney et al. (2011) and Scott and Monesson (2009), one could longitudinally expose infants from 3 months of age to emotionally sad music and then test whether the infants at 9 months would associate sad or happy music with own-race faces. However, ethical considerations would preclude such a manipulation. Alternatively, one could longitudinally expose infants from 3 months of age to faces belonging to a race other than their own to examine whether familiarity with the faces of this race will cause them to associate these other-race faces with happy, rather than sad, music at 9 months of age. In such studies, in addition to measuring visual attention, one needs also to measure infant emotional responses using such methods as BabyFACS (Oster, 2004). For example, one could use the infant visual attention and emotional responses together to ascertain whether the association between face race and music valence is established via emotional responses to the musical excerpts, to the faces, or to both. Overall, studies and measures of this kind will help disambiguate among different possibilities concerning how the linkage between face race and music emotional valence emerges.

The present findings showing that infants associate face race and music emotional valence is in accord with evidence from older children and adults. Extensive research with adults has consistently shown that adults perceive own-race individuals more positively than other-race individuals and treat them more favorably (Dunham et al., 2013; Hardin & Banaji, 2013; Pascoe & Richman, 2009). Recently, preschoolers have been shown to have implicit racial biases (Baron & Banaji, 2006; Qian et al., 2016). For example, when presented with a racially ambiguous face displaying positive or negative emotion, preschoolers, like adults, categorized the face with positive emotion as own-race, but the same face with negative emotion as other-race (Dunham et al., 2013; Raabe & Beelmann, 2011; Xiao et al., 2015). This race-based social categorization is similar to what was observed in the current study with infants.

The similarity between the infant and child–adult findings suggests that the associations that infants form between face race and music emotional valence might be a precursor to the implicit racial biases of children and adults (Baron & Banaji, 2006; Hugenberg & Bodenhausen, 2004). This possibility is supported by recent findings showing that perceptual factors can influence implicit racial bias. In particular, studies have reported that increasing perceptual experience with other-race faces can significantly reduce implicit racial bias in children and adults (Lebrecht, Pierce, Tarr, & Tanaka, 2009; Xiao et al., 2015). Thus, it is possible that there is a connection between emotional associations with own- and other-race faces in infancy and the emergence of racial biases in childhood. Future studies using a longitudinal design should test this intriguing hypothesis. If the associations of infants are shown to be connected to the pervasive racial biases in children and adults, then, considering their negative consequences at individual and societal levels (e.g. Banaji & Greenwald, 2013; Hardin & Banaji, 2013; Pascoe & Richman, 2009), early intervention in infancy may help to reduce such biases, potentially forestalling their emergence and related negative consequences later in life.

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