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Older infants' social learning behavior under uncertainty is modulated by the interaction of face and speech processing

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Abstract

The origin of face or language influences infants' perceptual processing and social learning behavior. However, it remains unclear how infants' social learning behavior is affected when both information are provided simultaneously. Hence, the current study investigated whether and how infants' social learning in terms of gaze following is influenced by face race and language origin of an interaction partner in an uncertain situation. Our sample consisted of 91 Caucasian infants from German speaking families. They were divided into 2 age groups: Younger infants were 5- to 8-month-old (n = 46) and the older infants 11- to 20-month-old (n = 45). We used a modified online version of the gaze following paradigm by Xiao and colleagues by varying face race (Caucasian, and Asian faces) and language (German and French) of a female actor. We recorded infants looking behavior via webcam and coded it offline. Our results revealed that older but not younger infants were biased to follow the gaze of own-race adults speaking their native language. Our findings show that older infants are clearly influenced by adults' ethnicity and language in social learning situations of uncertainty.

1 | INTRODUCTION

During the first year of life, the majority of infants from western countries grow up in a homogeneous environment with people belonging to their own race and speaking their native language. These early experiences shape infants' perception and recognition of faces and language stimuli (Maurer & Werker, 2014; Scott & Monesson, 2009) and influence their social learning behavior. Previous studies have already demonstrated that infants looking behavior is influenced by the face race (e.g., Xiao, Wu, et al., 2018) and native language of an interaction partner (Marno et al., 2016). However, until now, the role of both face and language of a social agent in infants' social learning behavior has not been studied jointly. Especially in situations of uncertainty, it is important to choose quickly whom we can trust. Therefore, we tested the extent to which younger and older infants' gaze following is influenced by the interaction partner's face race and native language in an uncertain situation. We modified the gaze following paradigm used by Xiao, Wu et al. (2018) such that not only the face race but also the language of a female actor was varied.

1.1 | Perceptual narrowing

From birth, infants are equipped with a wide range of visual and auditory skills. Most of these skills develop and specialize with experience, while others decline, a process known as “perceptual narrowing” (Maurer & Werker, 2014; Quinn et al., 2019; Scott & Monesson, 2009).

With regard to face perception, it has been shown that infants are predominantly exposed to faces of their own race (Rennels & Davis, 2008; Sugden et al., 2014). As a result, they become increasingly more efficient at recognizing and distinguishing own-race faces over other-race faces during their first year of life (Kelly et al., 2007; Spangler et al., 2013). The poorer recognition of other-race faces is also widely documented in adults and known as the other-race effect (Anzures et al., 2013; Meissner & Brigham, 2001). Evidence from training studies suggested that this phenomenon is caused by a lack of experience with faces of other races (Heron-Delaney et al., 2011).

Interestingly, the process of perceptual narrowing seems to be a cross-modal phenomenon (Kelly et al., 2007, 2009) occurring in visual face and auditory speech processing (Werker & Tees, 2002) at a similar time. For example, Krasotkina et al. (2018) provided evidence for a positive correlation between the ability to distinguish other-race faces and non-native speech tones. Accordingly, infants who were weak in distinguishing other-race faces also had difficulties distinguishing non-native speech tones (see also Xiao, Mukaida, et al., 2018). Thus, common developmental mechanisms seem to underlie perceptual narrowing in both domains (e.g., Krasotkina et al., 2018; Maurer & Werker, 2014).

1.2 | Social consequences and learning

Importantly, asymmetric exposure to own-race individuals compared to other-race individuals in everyday live also affects infants' social preferences in terms of face preferences. For example, 3-month-olds preferred to look at own race faces (Kelly et al., 2005; Liu et al., 2015). In addition, with increasing age, infants also appear to separate other people's faces into own-race and other-race groups. While 6-month-old Caucasian infants formed separate categories for various other-race faces, 9-month-olds formed a common category for faces of all foreign ethnicities (outgroup)—although these may differ greatly in appearance (Quinn et al., 2016, 2021). At the same time, infants also tend to associate own-race faces with positive emotions and other-race faces with negative emotions.

For example, Xiao et al. (2017) demonstrated that 9-month-olds looked longer at own-race faces combined with happy music and other-race faces combined with sad music. In an attempt to explain these developmental trends toward a preference for own-race faces, Lee, Quinn, and Heyman (2017) postulated that the infant's behavior of categorizing faces by race and associating familiar faces with positive emotions could be the basis for the emergence of so-called implicit racial biases which include automatic, not intended associations and stereotypes about certain groups of people. Lee, Quinn, and Heyman (2017) and Lee, Quinn, and Pascalis (2017) postulated a perceptual-social linkage hypothesis in which early childhood's experiences not only shape face perception, but also have social consequences as infants predominantly have contact with own-race individuals, who usually interact positively with them (Malatesta & Haviland, 1982). These positive experiences are generalized to other members of their own race (Lee, Quinn, & Heyman, 2017).

Similarly, asymmetric exposure to native language input compared to non-native input impacts infants' social preferences in terms of speaker- and language preferences as well. Already newborns preferred to listen to their native language to foreign languages (Moon et al., 1993). Additionally, 7-month-old infants listened longer to a melody introduced by a native speaker than to a melody introduced by a non-native speaker (Soley & Sebastián-Gallés, 2015). Moreover, infants rely on native speech information when they need to make decisions in social situations. For example, 10-month-olds were more likely to choose a toy offered by a native speaker rather than a toy offered by a non-native speaker (Kinzler et al., 2007, 2012). In the same manner, 12-month-olds preferred to choose food endorsed by a native speaker rather than a non-native speaker (Shutts et al., 2009). Marno et al. (2016) have shown that 5- and 12-month-olds looked longer at an object presented by a native speaker compared to a non-native speaker. Moreover, Buttelmann et al. (2013) showed that 14-month-olds were more likely to imitate a new action if a native speaker had previously demonstrated it. The authors argued that infants categorize individuals as in-group or out-group members based on their language, which in turn affects their social learning. Accordingly, infants direct their attention selectively to individuals who share the same cultural background and thereby enable efficient social learning. Thus, the expectation to obtain relevant information of an interaction partner seems to be the underlying motive for the early preference of native speakers (Begus et al., 2016).

Thus, it seems reasonable to assume that infants' abilities to discriminate and increasingly prefer the faces of their own ethnicity and language input from their native language have important consequences for their social learning. Especially when infants are in an uncertain learning situation, it can be assumed that they are guided by the behavior of a person who shares their facial ethnicity and native language. So far, there has been one study by Xiao, Wu et al. (2018) showing that this was indeed the case when facial ethnicity was available for infants as a social cue in an uncertain learning situation. The authors investigated the influence of a person's face race (Asian or African) on 7-month-old Chinese infants' learning behavior in terms of gaze following in an uncertain learning condition. Infants were shown videos of a female actor saying "Hey baby, look at this" in Mandarin. During a learning phase, the actor's head turn predicted the appearance of an animal with 25%, 50%, or 100% reliability. In the following test phase, the same actor looked to every corner of the screen, but no animal appeared. The ethnicity of the actor was varied across infants so that they saw either an Asian (own-race condition) or African woman (other-race condition). The results revealed that infants followed the actor's gaze regardless of her ethnicity when her prior gaze behavior was 100% reliable. Conversely, when gaze behavior was only 25% reliable, her gaze was not followed in any condition. However, the female actors' ethnicity influenced infants' behavior when her gaze behavior was 50% reliable during the learning phase. In this case, infants were more likely to follow the gaze of an own-race compared to other-race actor. This demonstrated that infants used statistical information and distinguished reliable informants from unreliable informants. Additionally, in situations of high uncertainty (when the actor's gaze was only 50% correct), infants relied on social information, such as the informant's face race, to guide their learning behavior. This finding is consistent with the perceptual-social linkage hypothesis mentioned above (Lee, Quinn, & Heyman, 2017). Thus, infants' tendency to associate own-race individuals with positive emotions (Xiao et al., 2017), as well as their increased negative responses to other race strangers, may have led them to especially trust and focus on individuals of their own ethnicity in situations in which other cues were uncertain. However, it has to be noted that so far there are mixed findings on whether race indeed influences infants' responses to strangers. Some found differences (e.g., Feinman, 1980) whereas others did not (e.g., Bronson, 1972; Cohen & Campos, 1974).

1.3 | The current study

Xiao, Wu et al. (2018) provided clear evidence that the face ethnicity of individuals can influence infants' social learning behavior in uncertain situations. However, it remains unclear whether language origin would modulate these effects. From birth, infants’ experience that in natural social interaction with an individual visual and auditory information are usually present simultaneously, highlighting the importance to study the impact of talking faces on infants` social learning. Therefore, based on the study by Xiao, Wu et al. (2018), we investigated whether infants' social learning in terms of gaze following is influenced by face race and language origin of an interaction partner in an uncertain situation. We tested infants with a modified version of the paradigm used by Xiao, Wu et al. (2018) such that not only the face race but also the language of the female actor varied.

As Xiao, Wu et al. (2018) have revealed that face race affected social learning only when the female actors` gaze behavior was 50% reliable, we only tested a reliability of 50% regarding the actors gaze behavior in the current study. The critical measure was how older and younger infants would use face ethnicity and language cues of a female actor to predict the appearance of an animal. Based on previous findings, we expected older infants to be more likely to use social cues provided by the female actor belonging to the same race and who speak their caregivers' language. Thus, we hypothesized a significant interaction of face and language information and expected that the older infants follow the gaze of the own-race, native speaking actor more often and the longest.

2 | METHOD

2.1 | Ethics statement

The present study was conducted according to guidelines laid down in the Declaration of Helsinki and the German Psychological Society with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the Research Ethics at the University of Giessen.

2.2 | Participants

For recruitment, infants' parents, from who we obtained addresses from the municipal administration or through recruiting at a local hospital, were contacted via invitation letter or phone call informing them about the purpose and procedure of the experiment. Moreover, additional infants were recruited

TABLE 1 Distribution and age (months) of the participants among the four conditions within the two age groups.

	N **European German**	***N*** **European French**	***N*** **Asian German**	***N*** **Asian French**
Younger	15 $M = 7.13$, $SD = 0.64$	10 $M = 6.70$, $SD = 0.68$	12 $M = 6.67$, $SD = 1.16$	9 $M = 7.11$, $SD = 0.78$
Older	11 $M = 15.91$, $SD = 2.47$	10 $M = 14.80$, $SD = 2.25$	12 $M = 14.50$, $SD = 2.47$	12 $M = 14.50$, $SD = 2.61$
Total	26	20	24	21

via the mailing list of the university or via the website "Kinder Schaffen Wissen" (www.kinderschaffenwissen.de). After participation, each child received a gift and a certificate of participation.

A total of 108 Caucasian infants were recruited for our study. The infants had to pass all learning and test trials. Moreover, they had to look at the actress face while she addressed the child at the beginning of each trial. Because of these criteria, we had to exclude seven infants from our analysis. The data from further 10 infants were excluded from the analysis due to direct contact to other-race individuals ($N = 2$) or because they were raised bilingually and tested in a non-native language condition ($N = 8$). Thus, the final sample consisted of 91 healthy and full-term infants (45 female and 46 male) aged 5–20 months. Infants were divided into 2 age groups: The younger infants were 5- to 8-month-old ($n = 46$, 22 female and 24 male, $M = 6.91$ months, $SD = 0.84$ months) and the older infants were 11- to 20-month-old ($n = 45$, 23 female and 22 male, $M = 14.91$ months, $SD = 2.45$ months). The distribution of participants across the different conditions is shown for each age group in Table 1. The age of the children did not differ significantly between the 4 conditions within the two age groups (all $ps > .05$).

Eighty-nine participants came from German-speaking families and were raised monolingual. Three infants grew up bilingually (German + one further language). However, since these infants were tested in the own-race + native language condition, it was assumed that their additional language experience would not affect the results. Importantly, none of the participating infants had regular contact to persons of Asian descent. In general, due to the Covid-19 pandemic, the majority of families had reduced their social contacts. Thus, infants had minimal contact to other people outside their families. Among the participating families, there were 77 families (87%) in which at least one parent had a university degree.

2.3 | Stimuli and apparatus

Due to the Covid-19 pandemic, testing had to be conducted online via a videoconference tool. The stimuli were presented on the family's laptop placed clearly visible in front of the child. As the participating families were equipped with different technical devices, the stimuli varied minimally in their presented size. The experiment and the infant's eye movements were recorded via webcam. According to Xiao, Wu et al. (2018) the experiment consisted of video sequences. Each video presented a woman and four corners of the screen (see Figure 1). In each sequence, the face of a woman, who belonged to either the European (own face race condition) or Asian (other face race condition) ethnic group, was presented. In order to minimize external differences between the women, they did not wear any makeup, had their hair tied back in a braid, and wore a gray T-shirt (see Figure 1). In the own-language condition, the woman addressed the infants while speaking in German, in the other-language condition, they addressed the infants in French. Within each language condition, the phrase "Hey baby,

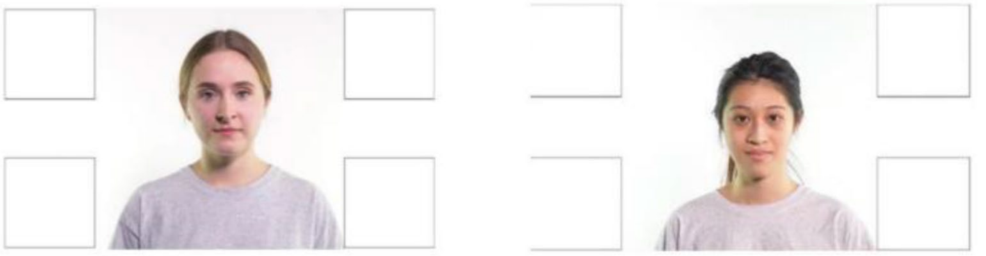

FIGURE 1 Female actors of the own face-race condition (left side) and other face-race condition (right side).

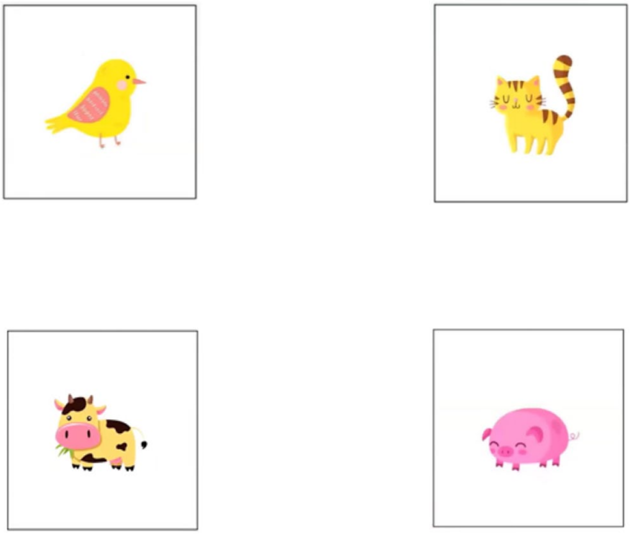

FIGURE 2 Animated animals in the corresponding corners of the screen.

look!" was presented in four different variations across trials. A female voice actor who could speak fluently German and French synchronized the videos. The voice recordings matched the lip movements of the women, resulting in synchronicity between the audio and visual recordings. This procedure ensured that the speech recordings were presented without accent and at the same time prevented infants from preferring a particular voice.

Each corner of the screen contained a black-framed box. During each learning trial (explained below), one of four different animated animals appeared in one of those boxes (see Figure 2). The following animals were presented, accompanied by sounds typical of each species: A yellow bird that rotated 360° (upper left corner), a yellow-brown cow that moved left and right (lower left corner), a yellow cat that got bigger and smaller (upper right corner) and a pink pig that moved up and down (lower right corner). The stimuli of the experiment were created in Adobe Premiere Pro (2019) and the script was programmed in E-Prime 3.0.

2.4 | Online procedure and design

The procedure of the main experiment was based on Xiao, Wu et al. (2018) with the exception that in our experiment face race and language stimuli varied across conditions. A between-subjects design was used with the dichotomous factors face race (European/Asian) and language (German/French). Each infant was randomly assigned to one of the four conditions: own face race + native language (European + German), own face race + foreign language (European + French), other face race + native language (Asian + German) or other face race + foreign language (Asian + French) condition. Infants were randomly assigned to the different conditions.

Before the online experiment consisting of a learning and test phase started, the experimenter ensured that the infant was positioned frontally to the screen and that the infant's eye movements were clearly visible. Then, a short video sequence (approximately 12 s), in which an animated animal appeared successively for 2.7 s in each corner of a black screen was played. The video was for attracting infants' attention to the screen and also ensured that the presentation of the video and audio recordings worked on the families' devices.

2.4.1 | Learning phase

The experiment started with a learning phase, which consisted of eight so-called valid and eight so-called invalid trials, presented in randomized order. During each trial, the face of the female actor appeared in the center of a white screen (see Figure 1), conveying direct eye contact to the infant. Approximately 0.50 s after the appearance of the actor, the infant was addressed by her for about 1.30 s in either German or French. Then, she turned her head in the direction of one of the four corners of the screen, each of which contained black-framed boxes. On the valid trials, an animated animal appeared in the gazed box for 3.0 s, accompanied by species-typical sounds. Thus, the female actors head turn predicted the appearance of the animal (e.g., she turned her head to Box A and the animal appeared in Box A). After the animal disappeared, the female actor again directed her gaze toward the child.

The invalid trials followed the same pattern, except that the animated animal appeared in a corner that was not gazed by the actor (e.g., she turned her head to Box A and the animal appeared in Box B). Since half of the trials were invalid, the female actors' gaze behavior was 50% reliable (see Figure 3). During all learning trials, the actor's gaze always turned to the same side (either left or right), but it varied across trials whether the face turned to the top or bottom corner. It was randomized across infants which side of the screen was gazed. In addition, the animals appeared either/only on the left or on the right side. As each animal was assigned to a particular corner, the infants saw two of the four animals across the learning trials. The top and bottom corners were targeted with equal frequency.

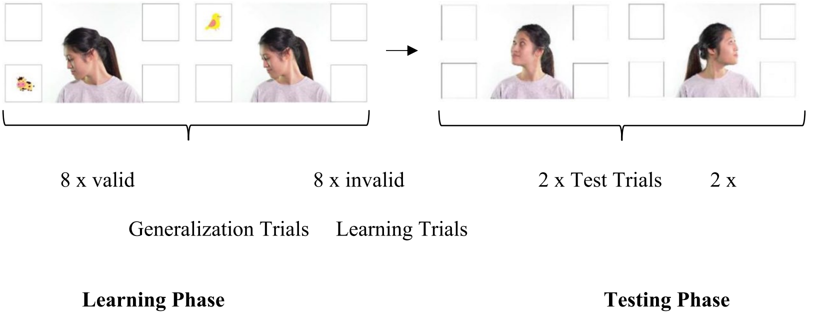

FIGURE 3 Exemplary representation of the learning and testing phase in the other-race condition.

2.4.2 | Testing phase

The learning phase was followed by a testing phase, which consisted of two test and two generalization trials. These trials were also presented in randomized order. In the test trials, the female actor gazed at each of the corners of the learning phase (e.g., Box A and B), but the corresponding animated animals did not appear. On the generalization trials, she turned her face to the corners she had not fixated during the learning trials (e.g., Box C and D). Again, no animated animals appeared (see Figure 3). In total, the experiment consisted of 20 video sequences (16 learning trials, 2 test trials, and 2 generalization trials), each lasting 7.5 s. Thus, the total time of the experimental session was 150 s.

We attached short video sequences of learning and test trials as Supporting Information S1 (see Appendix A).

2.5 | Data and statistical analysis

Two experienced research assistants measured offline manually (with a stopwatch) the looking times of the infants to the gazed boxes separately for the learning and test trials directly after the female actor had shifted her gaze to one of the corners. For each infant the webcam-video was aligned with the stimuli. Therefore, the coders were non-blinded to the experimental condition. However, of critical importance, they were blinded to our hypotheses. The student assistants used the video sequence at the beginning of the study to ensure that they could distinguish infants' gaze at each box correctly in the test phase. Therefore, the coders were able to code exactly which of the four boxes the infants were looking at. Figure 4 shows exemplary the looking behavior of one child at each of the four boxes.

We used the mean total looking time at the cued box as dependent variable because the children either looked at the experimenters' face or at the cued box. However, we analyzed the other non-gazed boxes of 25% of the infants. The mean looking times to the non-gazed boxes was overall extremely low

FIGURE 4 Exemplary looking behavior at each of the four boxes (top right, top left, bottom right & bottom left).

($M = 0.07$ s, $SD = 0.11$) and highly significantly ($p < .001$) lower than to the gazed boxes ($M = 0.58$ s, $SD = 0.56$) (see Supporting Information S1). Thus, infants looked systematically to the cued boxes and not to the non-cued boxes. As the boxes were white and empty (see Figure 1) there was no other reason than the gaze of the experimenter to look at the gazed boxes.

We calculated mean looking times to the gazed corners for the learning and testing phase. Since the looking times during the test and generalization trials did not differ significantly from each other, the mean looking times across test and generalization trials served as dependent measure. The second research assistant coded 25% of all trials. The interrater reliability for the learning phase was $r = .92$ ($p \leq .001$) and the interrater reliability for the test phase was $r = .79$ ($p \leq .001$). For the test phase, we analyzed additionally as dependent variable the total number of test trials the infants followed the adults gaze correctly.

We used SPSS 26.0 for all statistical analyses. We conducted an one-way between-subjects ANOVA with mean looking times to the gazed corners as dependent variable and *Face race* (European vs. Asian), *Language* (German vs. French) and *Age* (young vs. old) as between-subjects variables for the learning and test phase. Additionally, we conducted for the test phase another one-way between subjects ANOVA with total number of test trials the infants followed the adults gaze correctly as dependent variable and *Face race* (European vs. Asian), *Language* (German vs. French) and *Age* (young vs. old) as between-subjects variables.

3 | RESULTS

3.1 | Learning phase

First, we analyzed infants' mean looking times for the valid learning trials. An ANOVA with *Face race* (European vs. Asian), *Language* (German vs. French) and *Age* (young vs. old) as between-subjects variables was conducted. The ANOVA revealed that the mean looking times did not differ significantly between the different Face Races, $F(3,83) = 0.15$, $p = .701$, $\eta_p^2 = 0.002$, or Languages, $F(3,83) = 2.79$, $p = .099$, $\eta_p^2 = 0.033$. However, there was a significant main effect of Age, $F(1,83) = 55.82$, $p \leq .001$, $\eta_p^2 = 0.40$, indicating that older infants ($M = 2.66$ s, $SD = 0.56$ s) followed the gaze significantly ($p < .001$) longer than younger infants ($M = 1.64$ s, $SD = 0.72$ s). The interactions of Face race and Age, $F(3,83) = 0.21$, $p = .646$, $\eta_p^2 = 0.03$, as well as Language and Age, $F(3,83) = 0.11$, $p = .746$, $\eta_p^2 = 0.01$, were not significant. Moreover, we found a significant interaction between the factors Face race and Language, $F(1,83) = 4.04$, $p = .048$, $\eta_p^2 = 0.046$. However, post-hoc pairwise comparisons (Bonferroni corrected) did not reveal any significant mean looking time differences across conditions (all *ps* > .05).

For the invalid learning trials, neither Face race, $F(3,83) = 0.68$, $p = .411$, $\eta_p^2 = 0.008$, Language $F(1,83) = 2.31$, $p = .133$, $\eta_p^2 = 0.027$, Age, $F(3,83) = 0.98$, $p = .325$, $\eta_p^2 = 0.012$, nor corresponding interactions had a significant effect on infants' gaze following.

3.2 | Testing phase

In order to examine whether infants' looking times differed across conditions and age groups during the testing phase, an one-way between subjects ANOVA with *Face race* (European vs. Asian), *Language* (German vs. French) and *Age* (young vs. old) as between-subjects variables was conducted. The analysis revealed a significant main effect for Face race $F(1,83) = 14.14$, $p \leq .001$, $\eta_p^2 = 0.146$. Infants

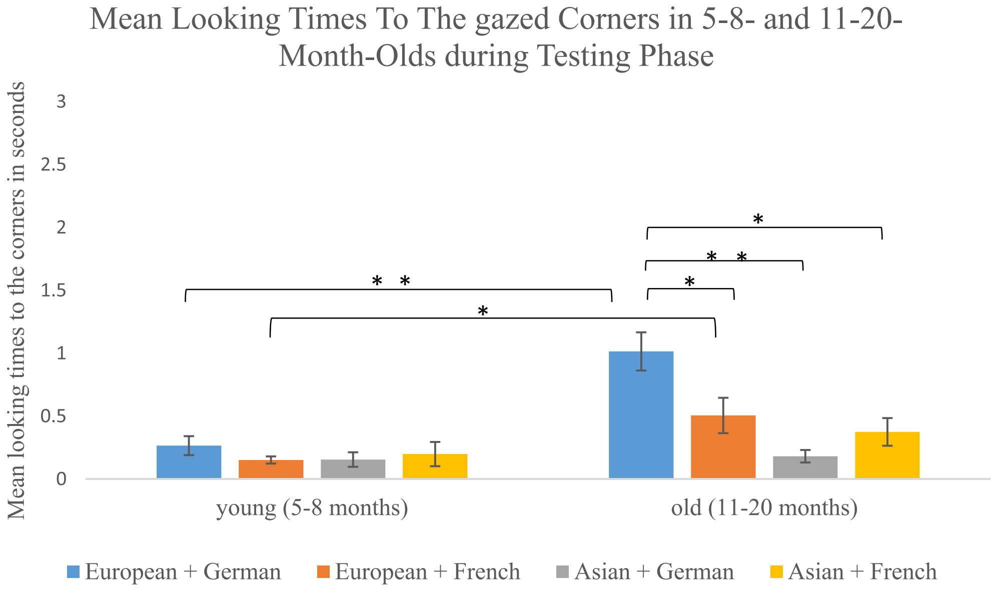

FIGURE 5 Mean looking times in s to the gazed corners for both age groups for the different conditions during testing phase. *$p \leq .05$, **$p \leq .001$, error bars are SEM.

followed the gaze of the European actor ($M = 0.48$ s, $SD = 0.48$ s) significantly longer than the gaze of the Asian actor ($M = 0.23$ s, $SD = 0.28$ s). Moreover, the ANOVA revealed that the mean looking times did not differ significantly between the different language conditions, $F(1,83) = 2.00$ $p = .161$, $\eta_p^2 = 0.02$, indicating that infants did not follow the gaze of an German speaking actor ($M = 0.38$ s, $SD = 0.46$) significantly longer than the gaze of an French speaking actor ($M = 0.31$ s, $SD = 0.35$). However, there was a significant main effect of Age, $F(1,83) = 22.83$, $p \leq .001$, $\eta_p^2 = 0.22$. Older infants ($M = 0.52$ s, $SD = 0.41$ s) followed the gaze of the actor significantly longer than younger infants ($M = 0.20$ s, $SD = 0.24$ s). Additionally, we found a significant Face race × Age interaction, $F(3,83) = 10.86$, $p = .001$, $\eta_p^2 = 0.17$, a significant Face race × Language interaction, $F(3,83) = 9.90$, $p = .002$, $\eta_p^2 = 0.107$ and a significant Face race × Language × Age interaction, $F(3,83) = 3.98$, $p = .049$, $\eta_p^2 = 0.046$.

To further analyze the significant interactions during the testing phase, we conducted separate ANOVAs for each of the two age groups.

For the younger infants, looking times did not differ significantly between the conditions during the test phase (*all ps* > .1). Younger infants spent the same amount of time gazing at corners regardless of the actor's Face race or spoken Language.

For older infants, the ANOVA with *Face race* (European vs. Asian) and *Language* (German vs. French) as between-subjects variables revealed a significant main effect for Face race $F(1,41) = 17.08$, $p \leq .001$, $\eta_p^2 = 0.294$. Older infants followed the gaze of the European actor ($M = 0.77$ s, $SD = 0.53$ s) significantly longer than the gaze of the Asian actor ($M = 0.28$ s, $SD = 0.31$ s). Moreover, the ANOVA revealed that the mean looking times did not differ significantly between the different language conditions, $F(1,41) = 1.83$ $p = .183$, $\eta_p^2 = 0.04$, indicating that the older infants did not follow the gaze of a German speaking actor ($M = 0.58$ s, $SD = 0.56$) significantly longer than the gaze of an French speaking actor ($M = 0.43$ s, $SD = 0.41$). Additionally, we found a significant Face race × language interaction, $F(1,41) = 9.07$, $p = .004$, $\eta_p^2 = 0.18$. As can be seen in Figure 5, Bonferroni-adjusted post-hoc analysis revealed that the mean looking times in the same race and native language condition (European + German: $M = 1.02$,

TABLE 2 Number of test trials the infants followed the female actors gaze correctly for both age groups for the different conditions.

	European face		Asian face	
	German	French	German	French
Young (5–8 m)	1.2 (1.1)	1.2 (0.8)	0.9 (0.9)	0.9 (0.9)
Old (11–20 m)	3.0 (0.9)	1.6 (1.3)	1.2 (1.1)	1.3 (1.0)

Note: Standard deviation in parentheses.

SD = 0.12) were significantly (p = .028) longer than in the same race and nonnative language condition (European + French: $M = 0.51$, $SD = 0.12$). Additionally, they were significantly longer ($p < .001$) than in the other race and same language (Asian + German: $M = 0.18$, $SD = 0.11$) and significantly longer ($p = .002$) than in the other race and other language (Asian + French: $M = 0.38$, $SD = 0.11$) condition.

The ANOVA with total number of test trials the infants followed the female actors' gaze correctly as dependent variable revealed a significant main effect for Face race $F(1,83) = 9.91$, $p = .002$, $\eta_p{}^2 = 0.107$. Infants followed the gaze of the European actor ($M = 1.72$, $SD = 1.24$) more often than the gaze of the Asian actor ($M = 1.09$, $SD = 0.97$). Moreover, the ANOVA revealed that the number of test trials the infants followed the adults gaze correctly did not differ significantly between the different language conditions, $F(1,83) = 2.17$ $p = .144$, $\eta_p{}^2 = 0.03$. The infants did not follow the gaze of the German speaking actor ($M = 1.52$, $SD = 1.27$) more frequently than the gaze of the French speaking actor ($M = 1.27$, $SD = 1.00$). However, there was a significant main effect for Age, $F(1,83) = 11.45$, $p = .001$, $\eta_p{}^2 = 0.12$. Older infants ($M = 1.76$, $SD = 1.26$) followed the gaze of the actor significantly more often than younger infants ($M = 1.07$, $SD = 0.93$). The interactions Face race × Age interaction, $F(3,83) = 3.10$, $p = .082$, $\eta_p{}^2 = 0.04$, Face race × Language interaction, $F(3,83) = 3.24$, $p = .076$, $\eta_p{}^2 = 0.038$ and Face race × Language × Age interaction, $F(3,83) = 3.47$, $p = .066$, $\eta_p{}^2 = 0.040$ were marginal significant. As can be seen in Table 2, the older infants followed the European German speaking female actor most frequently.

4 | DISCUSSION

The current online study aimed to examine whether infants were more likely to use social cues provided by an adult who belongs to the same ethnicity and who speaks the same language as their caregivers in situations of uncertainty. Our results revealed that older infants (11–20 months) were significantly biased to follow the gaze of own-race persons speaking their native language. In contrast, adults' face race and native language had no effect on the looking behavior in younger infants. Thus, our results suggest that older infants tend to follow cues more from people who share a similar cultural background in terms of face ethnicity and language, especially in uncertain situations.

Our results extend the finding of Xiao, Wu et al. (2018) by demonstrating that the face race and the native language of the adult significantly influenced the social learning behavior of older infants in uncertain situations. Those children were more likely to "trust" the adult when face and speech information were native. Specifically, as illustrated in Figure 5 and Table 2, infants from 11 to 20 months followed the gaze of the own-race adult speaking their native language most frequently and the longest. On the contrary, the social learning behavior of younger infants was not influenced by the adults' face race or language. The present study provides further evidence of strong interactions between face and speech processing during early child development. Previous studies have already demonstrated that face and speech processing specialize at a similar time and that they interact with each other (Clerc et al., 2022; Hillairet de Boisferon et al., 2021; Krasotkina et al., 2021). However, our study shows for the first time that those interactions also influence the social learning behavior in further child development. Hence, our results support the importance to study child's social learning behavior by varying face and language information. Moreover, our findings are in line with Lee, Quinn, and Heyman (2017) and Lee, Quinn, and Pascalis (2017) for whom, early childhood experiences not only shape face perception, but also have social consequences: Infants predominantly have contact with own-race individuals, who usually interact positively with them (Malatesta & Haviland, 1982). These positive experiences are generalized to other members of their own race (Lee, Quinn, & Heyman, 2017). Our results demonstrate that the asymmetrical exposure to native compared to non-native faces and languages can form significant social preferences potentially resulting in an early implicit social racial bias: In social situations of uncertainty, older infants trust own race native-speaking adults most likely. In contrast, younger infants were not able to use visual and auditory information simultaneously in uncertain situations. They spent the same looking times and number of test trials regardless of the adult's face race or spoken language. Our results differ from Xiao, Wu et al. (2018) who found that an adult's face race influenced younger infants' social learning behavior significantly. Specifically, 5- to 8-months old infants were more likely to follow the gaze of an own-race person rather than an other-race person in situations of uncertainty. However, contrary to our study, Xiao, Wu et al. (2018) did not vary the language of the female actor. The Asian or African woman always addressed the infant in Mandarin. Moreover, it could be that the younger infants in our study did not follow the gaze because they would have needed more time for familiarization. They were all born during the beginning of the Covid-19 pandemic and had dramatically reduced contacts with various talking faces in their first months of life. Hence, the simultaneous presentation of face and speech information on a laptop at home might have provided them with too complex information. In the study of Hillairet de Boisferon et al. (2021), videos of talking faces also seem to hinder infants' face recognition at that young age. Additionally, gaze following skills are still developing in the first year of life which also might have lowered young infants' responses (Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; D'Entremont et al., 1997). Thus, it could be that our task was too complex and cognitively too demanding for the younger infants. Additionally, it cannot be excluded that low-level, perceptual biases played a role in guiding infants' preference to follow the gaze of own-race faces speaking their native language. The process of gaze following includes several steps, for example, processing a face, understanding that the face transmits important information, and deciding whether to trust this information or not and to look away from the face to the gazed corner. We argued that face race and native language modulated the latter process (selective trust), but it cannot be excluded that those cues modulated this behavior earlier. For example, it could be that the processing of other-race faces or seeing own-race faces speaking a foreign language needed more cognitive resources. This could have led to a more challenging process of looking away from this face in order to learn something new compared to own race faces speaking the own language. The processing of the latter needed less cognitive load and did not offer anything new to learn and thus could have made it easier to look away from the face to the gazed corner. It would be interesting to investigate whether gaze following is more likely to be elicited by faces that require less cognitive load than by faces that require higher cognitive load.

4.1 | Limitations and directions for future research

The major limitations of this study were the number of participants and the online format. Our sample size was relatively small and thus the findings should be interpreted with caution and replicated in further studies. Additionally, all infants were tested with more or less slightly varying test conditions using a laptop from home. However, we instructed the parents with different technical devices in advance. Thus, the stimuli only varied minimally in their presented size. Originally, the study was designed like the study of Xiao, Wu et al. (2018) as an eye-tracking experiment but due to the Covid-19 pandemic, testing had to take place online via a videoconference tool. However, there are also many benefits of online studies. For example, they could increase participant diversity, improve reproducibility and collaborative possibilities and reduce costs for researchers and participants. Moreover, recent infant studies have shown that lab studies can be replicated online (e.g., Chuey et al., 2021; Smith-Flores et al., 2022). Hence, online testing can be a good option for infant research. Nevertheless, future studies should investigate infants looking behavior using a standardized eye-tracking paradigm in a lab to replicate our results. Additionally, future studies should also use other faces and languages to replicate our results.

Moreover, our participants grew up during the Covid-19 pandemic. Due to this pandemic, children only had minimal contact to people outside their families. It could be that the reduced contacts with various talking faces, especially during the first months of life, slowed down perceptual narrowing processes. Previous studies have already shown specific face processing modes in infants growing up during the Covid-19 pandemic (e.g., Kim et al., 2022; Yates et al., 2023). Furthermore, we did not study the effect of bilingualism on infants' social learning behavior. For example, Singh and colleagues (2019) demonstrated that bilingualism could reduce racial bias on a gaze following task. Hence, future studies should investigate the effect of bilingualism on face and speech processing in more detail. Additionally future studies should develop and validate intervention programs to prevent the early emergence of an implicit racial bias.

A major strength of our study was that we analyzed infants mean looking times as well as the total number of test trials the infants followed the adults gaze correctly. Hence, we had a qualitative as well as quantitative measure of infants' gaze following behavior. Another strength was that we varied face race and language of our stimuli. Former projects examined infants' social learning behavior most of the time varying solely face race or language (e.g., Xiao, Wu, et al., 2018). Such a study design allows only limited conclusions to be drawn. Finally, we used videos of talking faces instead of static pictures as stimuli, a setup closer to infants' everyday life. In contrast, previous studies often used static pictures (e.g., Clerc et al., 2022) instead of videos.

4.2 | Conclusion

Overall, our results show that older but not younger infants are more likely to use social cues provided by an interaction partner belonging to the same race and who speak their caregivers' language. In situations of uncertainty, gaze following behavior of older infants was clearly influenced by the face race and native language of the interaction partner. They follow the gaze of the own-race, native speaking actor more often and the longest. However, more systematic research is needed on the interaction of face and speech processing, early social preferences and the development of early implicit social race biases. Specifically, future studies should test different age groups with diverse face and language stimuli in a standardized eye-tracking paradigm.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest with regard to the funding source for this study.

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