Received: 27 September 2018 | Revised: 14 February 2019 | Accepted: 17 February 2019

DOI: 10.1002/dev.21851

RESEARCH ARTICLE

Developmental Psychobiology WILEY

Who can speak that language? Eleven-month-old infants have language-dependent expectations regarding speaker ethnicity

Lillian May | Andrew S. Baron | Janet F. Werker

Department of Psychology, University of British Columbia, Vancouver, BC, Canada

Correspondence
Janet F. Werker, Department of Psychology, University of British Columbia, Vancouver, BC, Canada.
Email: jwerker@psych.ubc.ca

Funding information
University of British Columbia; Social Sciences and Humanities Research Council of Canada, Grant/Award Number: 435-2014-0917

Abstract

Research demonstrates that young infants attend to the indexical characteristics of speakers, including age, gender, and ethnicity, and that the relationship between language and ethnicity is intuitive among older children. However, little research has examined whether infants, within the first year, are sensitive to the co-occurrences of ethnicity and language. In this paper, we demonstrate that by 11 months of age, infants hold language-dependent expectations regarding speaker ethnicity. Specifically, 11-month-old English-learning Caucasian infants looked more to Asian versus Caucasian faces when hearing Cantonese versus English (Studies 1 and 3), but did not look more to Asian versus Caucasian faces when paired with Spanish (Study 2), making it unlikely that they held a general expectation that unfamiliar languages pair with unfamiliar faces. Moreover, infants who had regular exposure to one or more significant non-Caucasian individuals showed this pattern more strongly (Study 3). Given that infants tested were raised in a multilingual metropolitan area—which includes a Caucasian population speaking many languages, but seldom Cantonese, as well as a sizeable Asian population speaking both Cantonese and English—these results are most parsimoniously explained by infants having learned specific language–ethnicity associations based on those individuals they encountered in their environment.

KEYWORDS
ethnicity, eye-tracking, infancy, language

Infants' early preference for and ability to learn about language is well documented. At birth, infants show a preference for listening to speech over nonspeech (Vouloumanos & Werker, 2007) and can discriminate the language(s) heard in utero from rhythmically distinct unfamiliar languages (Byers-Heinlein, Burns, & Werker, 2010; Mehler et al., 1988; Nazzi, Bertoncini, & Mehler, 1998). Moreover, infants show different patterns of neural activation in response to native versus non-native language soon after birth; patterns that become more distinct across the first months of life (May, Byers-Heinlein, Gervain, & Werker, 2011; May, Gervain, Carreiras, & Werker, 2018; Minagawa-Kawai et al., 2010; Sato et al., 2012; Vannasing et al., 2016). By 4 months, infants prefer their native language to a rhythmically similar non-native language (Bosch & Sebastián-Gallés, 1997; Molnar, Gervain, & Carreiras, 2014; Nazzi, Jusczyk, & Johnson, 2000), and by 5 months even prefer speakers of their native language over speakers of an unfamiliar language (Kinzler, Dupoux, & Spelke, 2007).

Language is more than just sounds and sentences—it is a system used to communicate between speakers. As such, as infants encounter language, they regularly encounter the faces of those producing spoken language. Attention to speakers of a language appears to provide infants opportunities to learn about language

more generally. Infants look preferentially at a face articulating the specific syllable or speech sound being heard at 2–4 months (Kuhl & Meltzoff, 1982; Patterson & Werker, 2003), but maintain this sensitivity to the match between heard and seen speech only for speech sounds used in the native language (Pons, Lewkowicz, Soto-Faraco, & Sebastián-Gallés, 2009; see also Danielson, Bruderer, Kandhadai, Vatikiotis-Bateson, & Werker, 2017). Indeed, young infants can also discriminate languages just by watching silent talking faces (Weikum et al., 2007), a sensitivity that changes across the first year of life as a function of experience (Sebastián-Gallés, Albareda-Castellot, Weikum, & Werker, 2012; see also Weikum et al., 2007).

In addition to providing cues to the properties of language, spoken language can offer information about who is speaking. By 5 months of age, infants look preferentially to human versus monkey faces when they hear speech, indicating that they have an early emerging expectation to hear speech from humans over other primates (Vouloumanos, Druhen, Hauser, & Huizink, 2009). Across the first months of life, infants become increasingly expert at discriminating individual voices (Johnson, Westrek, Nazzi, & Cutler, 2011), and can learn the match between an individual voice and face—even when both are initially unfamiliar—by 4 months of age (Bahrick, Hernandez-Reif, & Flom, 2005). Infants also show some evidence of generalizing to broader social categories including gender, age, and race. Specifically, infants can match gender in the voice to gender in the face—first with dynamic and later with static faces (Hillairet de Boisferon et al., 2015; Poulin-Dubois, Serbin, Kenyon, & Derbyshire, 1994; Richoz et al., 2017; Walker-Andrews, Bahrick, Raglioni, & Diaz, 1991). As well, at 4 and 7 months, infants can match adult and child voices to videos of adult and child speakers (Bahrick, Netto, & Hernandez-Beif, 1998).

Beyond co-occurrences with gender and age, differences in language often accompany differences in race or ethnicity. Interestingly, while the relationship between race and language may be intuitive among older children (see Hirschfeld & Gelman, 1997), scant research has explored infants' sensitivity to such pairings. While research illustrates that young infants attend to race/ethnicity (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005; Liu et al., 2015; see below), these studies do not indicate whether infants may further be tracking co-occurrences between language and race in their own milieu. Indeed, to date there has been only one study (Uttley et al., 2013) specifically examining whether young infants expect their own language to be spoken by members of their own ethnicity and/or a non-native language by individuals from a different ethnicity.

In their study, Uttley and colleagues (2013) asked whether infants differently associate their native language and an unfamiliar language with individuals of familiar and unfamiliar ethnicities. To do so, 6-month-old Caucasian monolingual English-learning infants were presented with either Caucasian or Asian faces paired with spoken English and/or Mandarin. In Experiment 1, infants were tested in a between-subjects sequential looking procedure in which they were shown a static image of either a Caucasian or Asian female face, and heard either spoken English or spoken Mandarin. One group of infants was assigned to the condition in which ethnicity and language matched (e.g., English with Caucasian faces), and the other group was assigned to the nonmatching condition. In this experiment, infants in the matching condition looked longer than did infants in the nonmatching condition. To ensure that the effect was not simply driven by one group of infants simply being longer lookers—irrespective of the stimuli—than the other group, a second experiment was run. In Experiment 2, one group of infants saw a Caucasian face and heard English or Mandarin across different trials, and the other group of infants viewed an Asian face under the same listening conditions. In this experiment, infants who viewed Asian faces looked longer when the faces were paired with Mandarin versus when paired with English, however, the looking behavior of infants who viewed Caucasian faces did not differ between the two language conditions.

Uttley and colleagues (2013) interpret these findings as evidence that infants are sensitive to the relationship between language and ethnicity, particularly for unfamiliar language and an unfamiliar ethnicity. However, multiple explanations exist for how infants may come to perceive a relationship between Mandarin and Asian faces. Many Mandarin-speaking individuals are of Asian descent, such that infants may have been exposed to this particular language–ethnicity pairing. Thus, one possibility is that infants' association between Asian faces and Mandarin language as observed in Uttley et al. (2013) is the result of a specific learned association. Another alternative explanation is that infants may have used a more general bias in which they associate any unfamiliar language with any unfamiliar (or less familiar) ethnicity. The authors attempt to disambiguate these possibilities in a third experiment, by testing infants' matching of Caucasian and Asian faces with *backwards* English and Mandarin. Infants' equal looking to the two ethnicities when paired with both backwards languages is taken as evidence that infants do not show a broader association between any unfamiliar sound with unfamiliar faces. However, previous studies have shown that backwards speech is not perceived as language, even by young infants (Dehaene-Lambertz, Dehaene, & Hertz-Pannier, 2002; May et al., 2018; Peña et al., 2003; Ramus, Hauser, Miller, Morris, & Mehler, 2000)—thus it is still unclear whether infants may associate any unfamiliar *language* with any unfamiliar ethnicity.

The present set of studies was designed to further explore infants' expectations about the ethnicity of individuals associated with familiar and unfamiliar languages, specifically examining whether infants are sensitive to specific associations between language and ethnicities based on their experiences, or if infants show a more general bias to pair any unfamiliar language with any unfamiliar ethnicity. To probe for age-related changes in sensitivity, Study 1 first tested English-learning Caucasian 6-month-old and 11-month-old infants on the association between Caucasian and Asian individuals and spoken English and Cantonese. Study 2 was designed to determine whether the language-ethnicity association observed in Study 1 resulted from specific experience, or whether it involved a more general matching of unfamiliar language with unfamiliar faces. Finally, Study 3 consisted of a replication and extension of Study 1. The replication consisted of ensuring the effect reported in Experiment 1

held with a new sample. The two experiments together provided a larger sample of infants with which to explore how infants' individual experience with people of different ethnicities/languages impacts their associations between language and ethnicities, and whether effects are seen in the detailed eye-tracking data collected in each study.

1 | STUDY 1

As described above, Uttley and colleagues (2013) reported that 6-month-old infants look more to Asian faces when paired with Mandarin language versus when paired with English. Study 1 expanded upon this finding, testing language-ethnicity pairings in infants of two ages (6 and 11 months). In the location where our studies were conducted, there are more than 200 different languages spoken by people from all over the world, with 46% of the population speaking a mother tongue other than English. (Statistics Canada, 2016), Given that the infants tested are from this population in which there are so many individuals of different ethnicities speaking so many different languages, we hypothesized that the infants may need to be at an older age (and with more amassed experience to different languages and ethnicities) to form sensitivity to specific pairings between languages and ethnicity.

A slightly different procedure from Uttley et al. (2013) was employed. Although Uttley et al. utilized a between-subjects design in which infants saw only a single face of one ethnicity or heard only one language, all infants in the present study sets heard segments of both native English and Cantonese, a non-native language, while viewing paired presentations of Caucasian and Asian faces. This design was intended such that associations between both languages and ethnicities could be examined within subjects for greater sensitivity. Moreover, because we wished to ascertain whether the language heard could guide infants' expectations of the ethnicity of the speaker, infants in this study first heard segments of one or another language play for 4 s, following which the images of both a Caucasian and an Asian face appeared side-by-side on the screen.

Differences in looking to own versus other-race faces were predicted between 6- and 11-month-old infants. Although previous research shows that infants at 3–4 months look longer at own-race faces (Bar-Haim et al., 2006; Kelly et al., 2005), recent studies suggest that 6-month-old infants look for equal amounts of time at own-race versus other-race faces, and by 9–11 months, look more at other-race versus own-race faces (Fassbender, Teubert, & Lohaus, 2016; Liu et al., 2015; Singarajah et al., 2017). Thus, we predicted that 6-month-old infants in Study 1 would show equal overall looking to both Caucasian and Asian faces, while 11-month-old infants would show greater overall looking to Asian versus Caucasian faces. The critical variable of interest for both ages, however, was how looking to Caucasian versus Asian faces would vary when faces were paired with English (familiar language) versus Cantonese (unfamiliar language). We predicted that if infants have different expectations about the speakers of English/Cantonese, they would show different patterns of looking to Caucasian versus Asian faces when paired with each of the two languages.

1.1 | Methods

1.1.1 | Participants

Sixteen full-term 6-month-old infants (6 males, 10 females; M_{age} = 6 months 18 days, Age range = 5 months 12 days to 7 months 18 days) and sixteen full-term 11-month-old infants (7 males, 9 females; M_{age} = 11 months 7 days, Age range = 10 months 18 days to 12 months 8 days) were included in Study 1. Infants were initially recruited through contact with parents at the local maternity hospital and community referral, and were invited to participate in the present study upon reaching the target age range. All infants were reported by their parent(s) to be hearing English at least 90% of the time and were of Caucasian/European ancestry. Seven additional infants were tested but excluded from final analyses due to fussiness (3), experimenter error (1), or technical issues with the eyetracker (3).

1.1.2 | Stimuli

Two 18-s segments of each English and Cantonese were used as language stimuli. For each language, two female native speakers (two English speakers and two Cantonese speakers) were recorded reading the English-Chinese bilingual children's book *The Mouse Bride* in a child-directed manner. All speakers were of approximately the same age (early mid-20s). From each speaker's recordings, one 18-s segment comprising an uninterrupted utterance was selected. The two segments of each language were chosen such that they did not contain the same portion of the story.

Photographs were taken of two Caucasian females and two East Asian (Chinese descent) females to be used as face stimuli. All four individuals were of approximately the same age (early mid-20s), and were photographed wearing the same neutral-colored t-shirt against a white background. None of the individuals used for face stimuli were the same speakers used for language stimuli.

1.1.3 | Procedure

Infants were tested in a darkened and sound-attenuated room, seated on the lap of their parent or caregiver, approximately 90 cm in front of a NEC 99 × 56 cm television screen. Parents/caregivers wore darkened sunglasses to limit any influence on their child's reaction. Visual images were presented to the infant on the television screen, and auditory stimuli were played though Altec Lansing speakers situated on either side of the television screen so they would be perceived as presented at mid-line. The speakers were hidden from the infant's view by a black curtain, and played language stimuli at approximately 65 dB. An experimenter controlled the experiment from a laptop computer running PsyScope software. Infants' looking times to the visual stimuli were collected via a Tobii

X60 eyetracker, placed approximately 66 cm in front of the infant, and recorded using Tobii Studio software.

Prior to beginning the experimental procedure, the infant's eye gaze was calibrated using the Tobii Studio 5-point infant calibration. After calibration, a 14-s pretest trial consisting of a checkerboard and a ringing bell sound occurred, to accustom infants to the presentation of sounds and images. Infants were then presented with up to 16 experimental trials in a counterbalanced order.

Each experimental trial (see Figure 1) began with one of the English or Cantonese language segments playing in conjunction with a video of a looming ball for 4 s. The display size of the ball video was 72 × 56 cm. After 4 s, the language segment continued to play, and the infant was presented with a pair of static images of faces on the television screen. Each pair consisted of one female Caucasian face and one female Asian face, with location to the left/right of the screen counterbalanced. Faces were presented on a black background, were 25 cm by 26 cm in size, and were located 11 cm apart as viewed on the television screen. Language and face stimuli were presented together for 14 s—thus, the 4-s looming ball presentation plus the face presentation comprised the entire 18-s language segment. Between each trial, an attention-getting video (a bouncing ball) was shown until the experimenter deemed the infant was attentive to the screen. At the end of 16 experimental trials, a final post-test trial occurred, consisting of the same checkerboard and ringing bell sound used in the pretest trial.

Sixteen test orders were counterbalanced across infants. Each order consisted of two blocks of eight trials, in which the second block was a repetition of the first block except that the left/right locations of Caucasian and Asian face pairs were swapped. Within each block, there were four English and four Cantonese trials presented in one of two counterbalanced orders.

Following the experimental procedure, parents were interviewed using a version of Bosch and Sebastián-Gallés' (1997) language exposure questionnaire that had been modified to include measures of ethnicity exposure (see Appendix A). Parents were asked whether there were any non-English speaking and non-Caucasian family members, caregivers, and/or friends in their child's life, and to provide estimates of how often and for how long the child saw these individuals each week. The questionnaire also inquired about the language and ethnic makeup of any baby groups attended and of the family's current and past neighborhoods. After answering these questions, parents were asked for overall estimates for the average total percentage of how often their child heard English versus other languages (across all times/individuals), and how often their child saw Caucasian individuals versus individuals of other ethnicities (across all times/individuals).

1.2 | Analyses

While the study was initially designed for infants to view 16 trials in total, several infants were unable to complete all 16 trials due to fussiness. Given that the second block of 8 trials was a repetition of the first 8 trials, only results from the first 8 trials were coded and analyzed, and infants who completed 8 or more trials were included in the final analysis.

The primary-dependent variable was infants' proportion looking to Caucasian versus Asian faces during English versus Cantonese trials. To calculate proportion looking, infants' total length of fixations to each face within each trial was collected, using the Tobii Fixation Filter. Trials were discarded from analysis if the infants' total fixation length to each face was less than 1 s. Proportion of looking to Caucasian versus Asian faces was then computed as a ratio of fixation length to each face type divided by total fixation length to both faces, and averaged across all remaining English and Cantonese trials for each infant.

1.3 | Results

A 2 × 2 × 2 repeated measures ANOVA was conducted to examine infants' proportion looking for the factors of language (English vs.

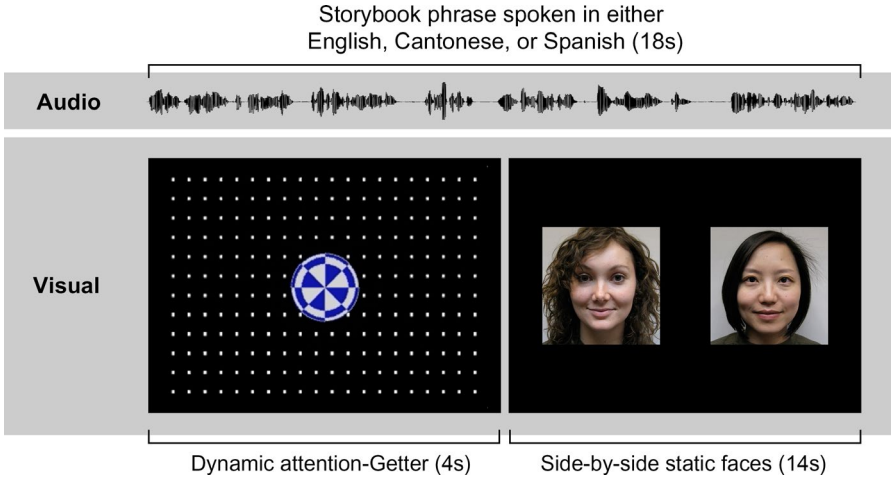


FIGURE 1 Schematic of an experimental trial in Studies 1–3. Infants heard an adult female speak phrases from a storybook in either English (all studies), Cantonese (Studies 1 and 3), or Spanish (Study 2) for 18 s. For the first 4 s, infants saw an "attention-getter" video of a looming ball; for the final 14 s, infants saw two static faces of adult females—one Caucasian and one Asian—presented side-by-side

Cantonese) and ethnicity (Caucasian vs. Asian faces) across both age groups (6 vs. 11 months). This analysis revealed a significant 3-way interaction between language, ethnicity, and age, $F = 9.994$, $p = 0.004$, $\eta^2_p = 0.250$. Follow-up analyses were subsequently conducted on each age group individually.

For 6-month-old infants, a significant main effect of ethnicity was observed, $F = 6.868$, $p = 0.019$, $\eta^2_p = 0.314$, such that infants looked more at Asian ($M = 0.550$, $SD = 0.076$) versus Caucasian ($M = 0.450$, $SD = 0.076$) faces. However, the interaction between language and ethnicity was not significant, $p = 0.601$, $\eta^2_p = 0.019$.

For 11-month-old infants, there was again a significant main effect of ethnicity ($F = 5.906$, $p = 0.028$, $\eta^2_p = 0.283$), such that infants looked proportionally more overall to Asian ($M = 0.543$, $SD = 0.072$) versus Caucasian faces ($M = 0.0457$, $SD = 0.072$). The interaction between language and ethnicity was also significant, $F = 17.661$, $p = 0.001$, $\eta^2_p = 0.541$. Follow-up paired t tests revealed that while there was no difference in proportion looking to Caucasian versus Asian faces in English language trials ($t = -0.019$, $p = 0.985$, $d < 0.001$), infants looked significantly more to the Asian ($M = 0.587$, $SD = 0.079$) versus Caucasian faces ($M = 0.413$, $SD = 0.079$) ($t = 4.370$, $p = 0.001$, $d = 0.257$) in Cantonese language trials.

Data on children's exposure to English versus other languages found that parents reported, on average, infants heard English 96.281% ($SD = 5.238\%$) of the time. This did not differ significantly for 6-month-old ($M = 97.313\%$, $SD = 3.381\%$) versus 11-month-old infants ($M = 95.250\%$, $SD = 6.557\%$), $p > 0.250$. Data on children's exposure to different ethnicities found that parents reported, on average, infants saw Caucasian individuals 87.656% ($SD = 14.665\%$) of the time, and Asian individuals 10.266% ($SD = 14.344\%$) of the time. Again, this did not differ significantly between 6-month-old ($M_{Cauc} = 88.688\%$, $SD_{Cauc} = 12.742\%$; $M_{Asian} = 8.844\%$, $SD_{Asian} = 12.066\%$) and 11-month-old infants ($M_{Cauc} = 86.625\%$, $SD_{Cauc} = 16.729\%$; $M_{Asian} = 11.688\%$, $SD_{Asian} = 16.592\%$), $ps > 0.500$.

1.4 | Discussion

Results from Study 1 (see Figure 2) indicate that at 11 months—but not at 6 months—infants detect a relationship between Asian individuals and Cantonese language (or alternatively, a lack of a relationship between Caucasian individuals and Cantonese.). Specifically, even though 6-month-old infants were unexpectedly found to look more to Asian versus Caucasian faces overall, they did not show a difference in looking to the faces when paired with English versus Cantonese language. Crucially, 11-month-olds looked more to Asian versus Caucasian faces when hearing Cantonese, yet looked similarly to Asian and Caucasian faces when hearing English. Thus, by 11 months of age, infants appear to expect that Asian faces are more likely to speak Cantonese than are Caucasian faces.

Interestingly, the results with 6-month-olds in the present study differ from those of Uttley and colleagues (2013), in which infants of the same age were found to look longer at Asian faces when paired with Mandarin versus with English. One possible explanation is that differences in study design may have contributed to the discrepancies in results. In particular, the present study explored infants looking to both ethnicities and both languages together (versus in a between-subjects design as used by Uttley et al., 2013), which may be more challenging for younger infants. In our within-subjects design, infants were presented with two languages and two ethnicities, and their expectations of associations between both were assessed. While this allowed us to assess infants' expectations about the link between both own language and own-race faces and between non-native language and other-race faces, this design is also potentially more challenging than the between-subjects method utilized by Uttley et al. in which infants must attend to and make inferences about only one language or one ethnicity. Alternatively, it may be that the multilingual, multiethnic population in which the infants studied in the present work are raised may contribute to later development of specific language-ethnicity pairings.

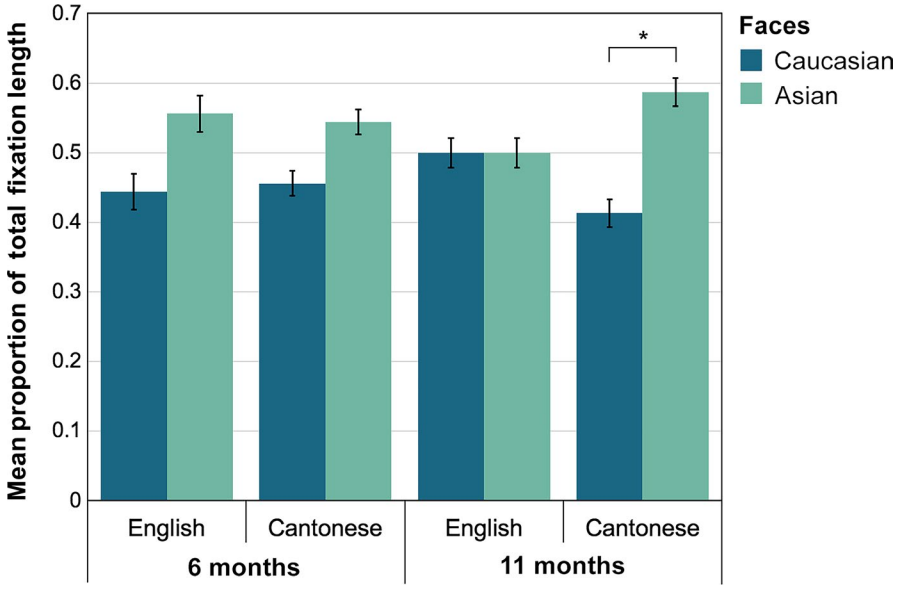


FIGURE 2 Results from Study 1. The looking behavior of the 6-month-old infants did not differ significantly between the Caucasian and Asian faces, regardless of whether the infants were hearing English or Cantonese. The 11-month-old infants looked significantly more to the Asian faces versus the Caucasian faces when hearing Cantonese ($p = 0.001$), but not when hearing English ($p = 0.985$)

In this work, infants showed sensitivity to a relationship between Cantonese language and Asian faces by 11 months of age. However, results from Study 1 still leave unanswered the question of *how* infants come to be sensitive to the relationships between languages and ethnicity. As described previously, it may be that infants only perceive specific associations that are based upon the language–ethnicity pairings they have encountered in their environment. Indeed, the vast majority of Cantonese speakers in the city of testing are of Asian ethnicity. Moreover, the infants tested in the current set of studies are from a community with a large Asian population (approximately 31% of the population are of East and Southeast Asian descent; Statistics Canada, 2016), many of whom speak Cantonese all or some of the time. It is not unreasonable that by 11 months, infants raised in this environment might come to detect a correlation between Asian individuals and spoken Cantonese from their daily experiences, and use this knowledge to direct looking in Study 1. Alternatively, it may be that infants rely on a more general bias to associate any unfamiliar language with any unfamiliar ethnicity. Study 2 was thus designed to distinguish these possibilities.

2 | STUDY 2

Study 2 examined whether 11-month-old infants' association between Asian faces and Cantonese as reported in Study 1 is the result of a specific association based on a specific language-ethnicity pairing in the infants' environment versus the result of a broader bias to associate any unfamiliar language with individuals of an ethnicity different than their own. As described previously, in Uttley et al.'s work, it was found that infants did not look differently to Asian and Caucasian faces when paired with native versus non-native backwards language. However, given that infants do not process backwards speech as language, here we wished to explore whether infants might expect any unfamiliar language to go together with individuals of an unfamiliar ethnicity. Study 2 thus employed the same methodology as Study 1, except that Caucasian and Asian faces were paired with English and Spanish language. In contrast to Cantonese, very few Asian individuals speak Spanish—particularly in the community from which these infants were recruited, making it improbable that any association infants demonstrate between these faces and languages is due to specific experience. Testing infants' looking to Asian versus Caucasian faces when paired with English and Spanish therefore allowed us to explore the specificity of infants' expectations of the individuals associated with different languages. Based on the results of the previous study, only 11-month-old infants were tested in Study 2.

2.1 | Methods

2.1.1 | Participants

Data from sixteen 11-month-old infants was included in Study 2 (6 males, 10 females; M_{age} = 11 m and 5 days, Age range = 10 months 16 days to 11 months 29 days). Infants were recruited in the same manner as Study 1. All infants were reported by their parent(s) as hearing English at least 90% of the time, and were of Caucasian/European ancestry. Four additional infants were tested, but were excluded from final analyses due to fussiness (2) or technical errors with the eyetracker (2).

2.1.2 | Stimuli

The stimuli used in Study 2 were the same as in Study 1, except that Cantonese language stimuli were replaced with Spanish language stimuli. To create the Spanish stimuli, two female native Spanish speakers (early mid-20s) were recorded reading Spanish translations of the children's story *The Mouse Bride* in a child-directed manner. From these recordings, one 18-s segment was chosen from each speaker, such that the segments did not overlap in content.

2.1.3 | Procedure

The same procedure used in Study 1 was employed, except that Cantonese language trials were replaced with Spanish language. As in Study 1, two blocks of 8 trials were presented, but only the first block of 8 trials was used for analysis.

When completing the language/ethnicity exposure questionnaire, one parent abstained from estimating the overall percent of time their child was exposed to English versus other languages, and three parents abstained from estimating the overall percent of time their child was exposed to Caucasian individuals versus individuals of other ethnicities. All parents answered questions about the language use and ethnicity of family members, friends, and caregivers.

2.2 | Results

A 2 × 2 repeated measures ANOVA was conducted on infants' proportion looking time over the factors of language (English, Spanish) and ethnicity (Caucasian, Asian faces). Similar to Study 1, a main effect of ethnicity was observed, $F = 15.539$, $p = 0.001$, $\eta^2_p = 0.509$, such that infants looked overall more to Asian ($M = 0.561$, $SD = 0.060$) versus Caucasian faces ($M = 0.439$, $SD = 0.060$) faces. In contrast to Study 1, the interaction between language and ethnicity was not significant, $p = 0.741$, $\eta^2_p = 0.008$.

Data on children's exposure to languages and ethnicity found that parents reported, on average, infants in Study 2 heard English 96.688% ($SD = 3.281\%$) of the time, and saw Caucasian individuals 83.267% ($SD = 7.324\%$) and Asian individuals 13.538% ($SD = 9.098\%$) of the time—comparable to, but slightly more than in Study 1.

2.3 | Discussion

The 11-month-old infants tested in Study 2 did not show any difference in looking to Asian versus Caucasian faces when paired with English versus when paired with Spanish (see Figure 3). This contrasts with the results from Study 1 in which infants looked more to

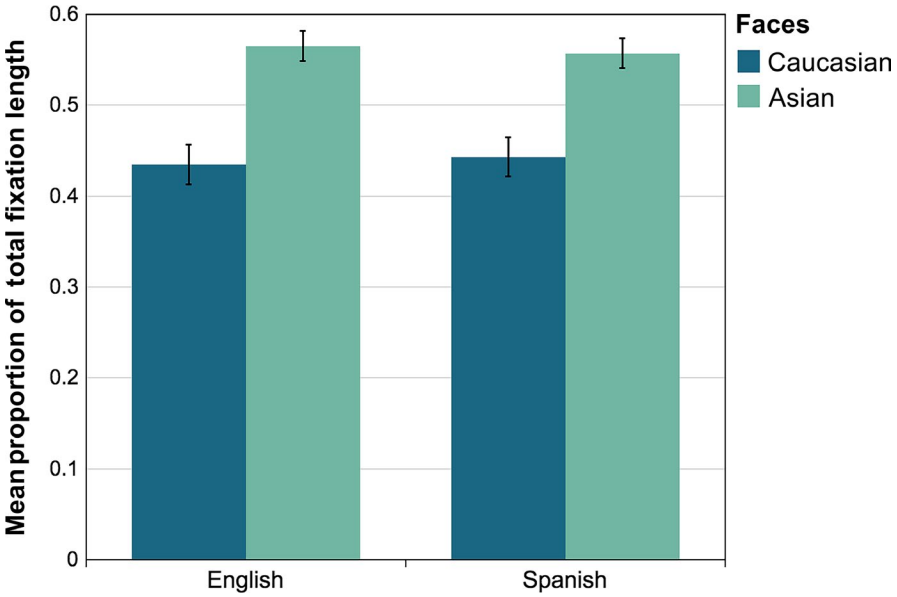


FIGURE 3 Results from Study 2. While 11-month-olds looked significantly more at Asian versus Caucasian faces overall (p = 0.001), no interaction was found with language (p = 0.741)

Asian versus Caucasian faces when paired with Cantonese. These findings imply that infants do not simply associate any unfamiliar language with faces of an unfamiliar or less-familiar race. Instead, the findings observed in Study 1 (and possibly that reported by Uttley et al., 2013) appear to be the result of a specific, learned association based on the language-ethnicity pairings infants see in their environment.

3 | STUDY 3

Studies 1 and 2 indicate that at 11 months, infants are sensitive to a relationship between Cantonese language and Asian individuals, but not to an association between any unfamiliar language and any unfamiliar ethnicity. That, by 11 months, infants can learn specific relationships between an abstract group variable such as ethnicity and another abstract group variable, the language being spoken, is an impressive feat of learning. To provide further support for these results, we sought to replicate the findings from Study 1 with a novel sample of infants.

By testing a second sample of 16 infants, we were also able to combine the data from the two studies to address the question of whether individual differences in exposure to own versus other-race faces and native versus unfamiliar language contribute to infants' sensitivity to language–ethnicity associations. Previous research has shown that infants' experience can impact their sensitivity to and their scanning patterns of the face of different ethnicities. For example, work by Ellis, Xiao, Lee, and Oakes (2017) has shown that the diversity of the community in which they are raised influences 6- to 8-month-old infants' scanning static images of faces. In the Ellis et al.'s study, while 8-month-old infants from an ethnically homogeneous community looked more at the eyes and nose of own-race faces but more at the mouth of other-race faces, infants from an ethnically heterogeneous community looked similarly at faces of both races. Further, infants at 6 months from ethnically homogeneous and heterogeneous communities showed differences in the scan path amplitudes of viewing own and other race faces, with infants from an ethnically homogeneous community showing shorter amplitudes.

Research has also suggested that infants scan faces differently when listening to native versus non-native languages. In a widely cited study, Lewkowicz and Hansen-Tift (2012) exposed 4- to 12-month-old English-exposed infants to Caucasian faces speaking English and Spanish, and measured infants' scanning of eye and mouth regions. Their findings revealed that for both languages, infants at 4 months looked more to the eyes region; at 6 months looked equally to eyes and mouth regions; and at 8 months looked more to the mouth region. Yet, at 12 months, infants' scanning varied based on language: for faces speaking the native language, infants looked equally at eyes and mouth regions, but for faces speaking a non-native language, infants looked more at the mouth, presumably to gain additional (visual) information about the speech being heard. Relatedly, Kubicek et al. (2013) found that 12-month-old infants increased looking to the eyes versus to the mouth when silent talking faces were paired with native language, yet increased looking to the mouth versus to the eyes when paired with non-native language.

Still unexplored is how experience with other languages and other-race faces influence infants' sensitivity to the associations between language and ethnicity. Specifically, none of the eye-tracking studies to date have investigated how face scanning varies as a function of the joint contribution of native versus non-native language, and native versus non-native ethnicity. By combining the samples from Study 1 and Study 3, we gain additional power to address both the contribution of individual differences in exposure to non-native faces and non-native language on the expectation for their association, as well as to analyze eye-tracking data in more detail.

As noted above, while infants' looking to eye, nose, and mouth regions of the face appears to be influenced by ethnicity and language,

no studies have examined how these two factors may interact. Three outcomes are possible: (a) looking patterns may be entirely determined by the language being spoken, in which case in this work, infants should look more to the mouth for both Caucasian and Asian faces when they hear Cantonese, and equally to the eye and mouth regions when they hear English; (b) looking patterns may be determine by the ethnicity of the face, in which case infants should look more to the mouth of the Asian face regardless of which language is being spoken; or (c) looking patterns may be determined by the intersection of language and ethnicity. Thus, by also analyzing the eye-tracking data, we can determine whether it is the language being spoken, the ethnicity of the face, or their interaction that drives infants' scanning patterns.

3.1 | Methods

3.1.1 | Participants

Sixteen full-term 11-month-old infants were tested (12 males, 4 females; M_{age} = 11 months 9 days, Age range = 10 months 16 days to 12 months 13 days). Infants were recruited in the same manner as Study 1. All infants were reported by their parent(s) as hearing English at least 90% of the time and were of Caucasian/European ancestry. An additional 12 infants were tested, but were excluded from final analyses because of failure to provide sufficient data due to fussiness (5) or movement (1); parent interference (3); or technical issues with the eyetracker (3).

3.1.2 | Stimuli and procedure

The stimuli and procedure were identical to those used in Study 1. When completing the language/ethnicity exposure questionnaire, one parent abstained from estimating the overall percent of time their child was exposed to English versus other languages, and four parents abstained from estimating the overall percent of time their child was exposed to Caucasian individuals versus individuals of other ethnicities. All parents answered questions about the language use and ethnicity of family members, friends, and caregivers.

Analysis

Primary analyses were conducted in the same manner as Study 1. Secondary analyses were conducted on the effects of infants' exposure to different languages and ethnicities and on infants' looking to areas of interest within the faces. These analyses were performed using the combined sample of infants from Studies 1 and 3 (N = 32).

The influence of infants' exposure to different languages and ethnicities on their looking patterns was examined using three variables. We conducted analyses using parents' estimates of the overall percentage of time their child was exposed to English versus other languages and the overall percentage of time their child was exposed to Caucasian individuals versus individuals of other ethnicities. In addition, based on parents' responses to the language/ethnicity questionnaire, infants were classified into two groups based on whether or not they had regular exposure to one or more significant non-Caucasian individual in their life. A significant non-Caucasian individual was defined as a family member, caregiver, or friend that the parent reported the child saw more than 1 hr a week (on average) or more than "occasionally."

For region of interest (ROI) analyses, regions were defined for eyes, mouth, and nose areas. Each region was drawn in a rectangle shape that encompassed the corresponding face area of all faces, and all three regions were of equal size (see Figure 4). ROI proportions were calculated by dividing the time the infant looked at the target region as a proportion of total looking to the face during a given trial (see Liu et al., 2015).

3.2 | Results

3.2.1 | Replication analysis: Study 3 data only

As in Study 1, a 2 × 2 repeated measures ANOVA was conducted on infants' proportion looking time over the factors of language (English vs. Cantonese) and ethnicity (Caucasian vs. Asian faces). A significant main effect of ethnicity was observed (F = 12.389, p = 0.003, η^2_p = 0.452), where infants looked proportionally more to Asian (M = 0.552, SD = 0.060) versus Caucasian faces (M = 0.448, SD = 0.060) overall. The interaction between language

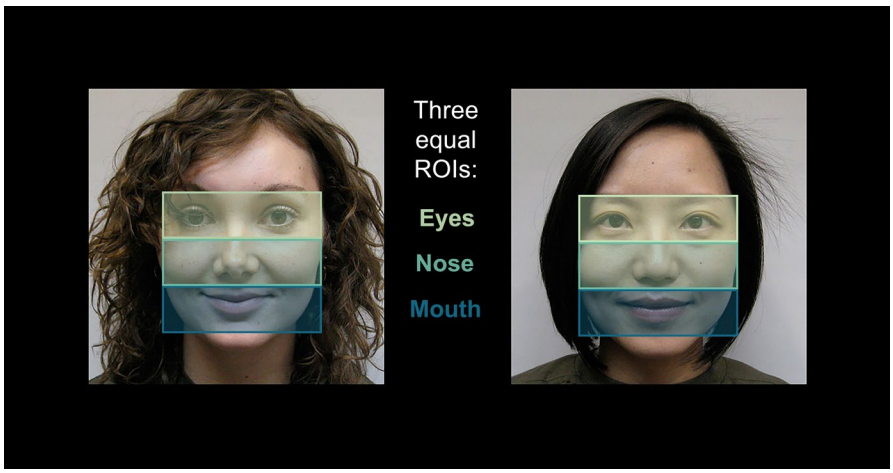


FIGURE 4 Regions of interest in Study 3. Three regions of interest (ROIs) were specified on each face—eyes, nose, and mouth—which were all of identical size

and ethnicity was also significant, $F = 5.749$, $p = 0.030$, $\eta^2_p = 0.277$. Replicating what we found in Study 1, follow-up paired t tests revealed that while there was a nonsignificant trend toward looking more to Asian ($M = 0.533$, $SD = 0.070$) versus Caucasian faces ($M = 0.467$, $SD = 0.070$) during English trials ($t = 1.872$, $p = 0.081$, $d = 0.967$), infants looked significantly more to the Asian ($M = 0.572$, $SD = 0.066$) versus Caucasian faces ($M = 0.427$, $SD = 0.066$) in Cantonese language trials ($t = 4.379$, $p = 0.001$, $d = 2.261$).

Data on children's exposure to languages and ethnicity revealed that parents reported, on average, infants in Study 3 heard English 97.750% ($SD = 2.955\%$) of the time, and saw Caucasian individuals 90.667% ($SD = 11.782\%$) and Asian individuals 5.000% ($SD = 7.977\%$) of the time.

3.2.2 | Combined analyses: Data from Study 1 and 3

The influence of infants' exposure to different languages and ethnicities on looking time was examined using the combined sample of infants from Studies 1 and 3. For the first set of analyses, parents' estimated overall percent exposure to English and to Caucasian individuals were entered as covariates in separate ANOVAs examining infants' looking across language and ethnicity. In both ANOVAs, there were no significant interactions between looking and language/ethnicity exposure, ps > 0.250.

For the next analysis, infants were classified according to whether parents reported they had regular exposure to one or more significant non-Caucasian individuals. Of the 32 infants, 15 met the criterion for having such an individual (or individuals) in their life (nine infants tested in Study 1, and six infants tested in Study 3). This variable was analyzed as a between-subjects factor in an ANOVA along with the within-subjects factors of language and ethnicity. A significant interaction between whether infants had a significant non-Caucasian individual in their life and looking to Caucasian versus Asian faces emerged, $F = 4.826$, $p = 0.036$, $\eta^2_p = 0.139$. Follow-up tests revealed that while there was significantly greater overall looking to Asian versus Caucasian faces for infants who did not have a significant non-Caucasian individual in their life ($M_{Asian} = 0.570$, $SD_{Asian} = 0.085$; $M_{Caucasian} = 0.430$, $SD_{Caucasian} = 0.085$; $F = 25.998$, $p < 0.001$, $\eta^2_p = 0.619$), infants who did have one or more such individuals in their life showed no significant difference in looking to Asian versus Caucasian faces ($p = 0.205$). The 3-way interaction between infants' exposure to non-Caucasian individuals and language and ethnicity was nonsignificant, $F = 2.448$, $p = 0.128$, $\eta^2_p = 0.075$, but did reveal an interesting trend. Infants who had regular exposure to one or more significant non-Caucasian individuals showed a significant interaction between language and ethnicity, $F = 26.898$, $p < 0.001$, $\eta^2_p = 0.658$, such that they looked more to Asian faces during Cantonese trials ($M = 0.565$, $SD = 0.076$) as compared to English trials ($M = 0.480$, $SD = 0.072$). For infants who did not have regular exposure to a significant non-Caucasian individual, the interaction was in the same direction with greater looking to Asian faces during Cantonese ($M = 0.592$, $SD = 0.068$) versus English trials ($M = 0.548$, $SD = 0.068$), but with a lower effect size, $F = 4.489$, $p = 0.0501$, $\eta^2_p = 0.219$.

To examine infants' looking to areas of interest within the face stimuli, a 2 × 2 × 3 repeated measures ANOVA was conducted with the factors of language, ethnicity, and region (proportion looking to eyes, mouth, and nose regions) using the sample of infants from both Studies 1 and 3. A main effect of region was observed, $F = 11.092$, $p < 0.001$, $\eta^2_p = 0.425$. Follow-up tests revealed that infants looked proportionally more at nose regions ($M = 0.355$, $SD = 0.209$) than at eye regions ($M = 0.123$, $SD = 0.204$; $F = 22.819$, $p < 0.001$, $\eta^2_p = 0.424$) and mouth regions ($M = 0.212$, $SD = 0.204$; $F = 6.437$, $p = 0.016$, $\eta^2_p = 0.172$). There was no significant difference in looking to eye versus mouth regions ($p = 0.113$, $\eta^2_p = 0.079$). A significant interaction between language and region also emerged, $F = 3.781$, $p = 0.034$, $\eta^2_p = 0.201$. Follow-up tests revealed that proportion looking to the eyes was greater in English trials ($M = 0.145$, $SD = 0.170$) versus Cantonese trials ($M = 0.100$, $SD = 0.119$), $F = 7.407$, $p = 0.011$, $\eta^2_p = 0.193$, while no effects of language were seen for the mouth ($p = 0.249$, $\eta^2_p = 0.043$) or nose regions ($p = 0.986$, $\eta^2_p < 0.001$). No significant interaction was observed between ethnicity and region ($p = 0.754$, $\eta^2_p = 0.019$) or in the 3-way interaction between language, ethnicity, and region ($p = 0.180$, $\eta^2_p = 0.108$).

A final set of analyses was conducted to examine whether reported exposure to language or ethnicity modulated the infants' facial scanning patterns across language and ethnicity; no significant interactions were found, ps > 0.250.

3.3 | Discussion

The results from Study 3 replicate and confirm those of Study 1: a novel sample of 11-month-old infants looked more to Asian faces when paired with Cantonese than they did when paired with English (see Figure 5). This finding further supports the conclusion that infants in the population tested have learned a specific relation between Asian faces and the Cantonese language by 11 months. Strengthening this conclusion is the finding that when the data are combined from Studies 1 and 3, the effect size for looking to Asian faces when hearing Cantonese is larger for those infants whose parents report they regularly interact with at least one significant individual who is non-Caucasian (see Figure 6). Taken together, these results support the hypothesis that there is sufficient opportunity for infants in the population tested to learn the relation between Cantonese and Asian faces. The detailed eye-tracking data revealed that infants looked more to the eyes versus the mouth when hearing English versus when hearing Cantonese (see Figure 7), which is consistent with previous work examining infants' scanning of talking faces (Lewkowitz & Hansen-Tift, 2012). However, infants did not look more to the mouth than the eyes when hearing unfamiliar Cantonese. This latter observation constitutes a failure to replicate other reported findings (e.g., Kubicek et al., 2013). This discrepancy may be due to the use of static faces in the current work versus talking faces in the previous literature. For example, infants are able to match gender in the face and voice at 6-months if the faces are

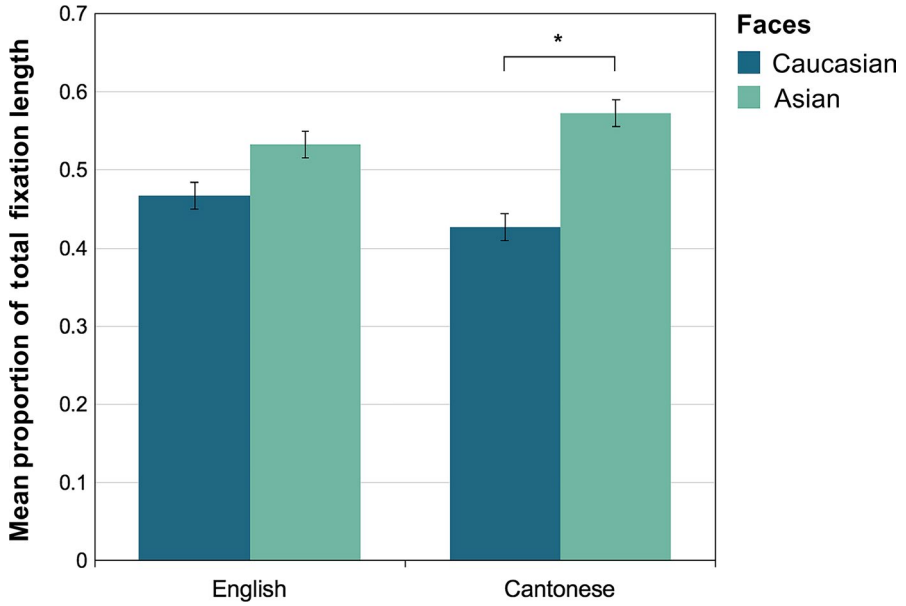


FIGURE 5 Results from the novel group of 11-month-olds (N = 16) tested in Study 3. The infants looked significantly more to Asian faces versus Caucasian faces when paired with Cantonese (p = 0.001), but not when paired with English (p = 0.081)

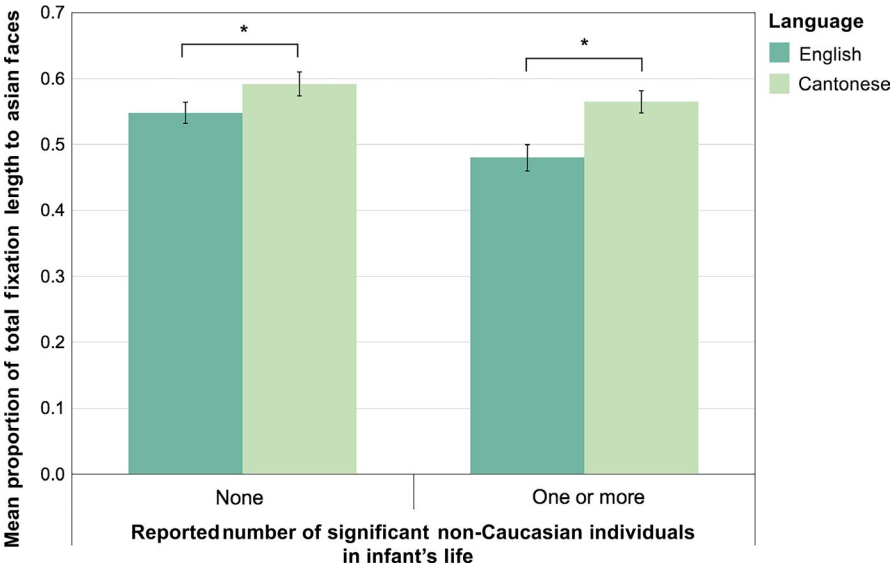


FIGURE 6 Proportion looking to Asian faces for combined sample of infants from Studies 1 and 3, separated by those infants whose parents reported regular exposure to one or more significant non-Caucasian individuals in their infant's life, and infants whose parents reported no such exposure. Infants (N = 15) with regular exposure to non-Caucasian individuals looked more to Asian versus Caucasian faces when paired with Cantonese versus English (p < 0.001, η^2_p = 0.658), as did infants (N = 17) whose parents did not report regular exposure (p = 0.05, η^2_p = 0.219), but with a lower effect size

moving (Walker-Andrews et al., 1991), but not until 8–9 months if they are static (Poulin-Dubois et al., 1994). Moreover, even without speech, there are developmental differences in the processing of individual identity (Xiao et al., 2015) when infants are presented with moving versus static faces.

Our results also provide mixed evidence that infants attend differently to their own versus other-race faces. While our findings follow those of other studies demonstrating that infants at around 11 months look overall more at other-race faces (Liu et al., 2015; Singarajah et al., 2017), our data do not replicate previous work reporting that at 9 and 11 months of age, infants look more to the eyes when scanning videos of own versus other-race faces (Xiao, Xiao, Quinn, Anzures, & Lee, 2013; Wheeler et al., 2011). Given that infants' detailed scanning patterns were, in contrast, found to be impacted by language, it may be that infants' attention is more heavily influenced by language than by ethnicity at this age—a possibility bolstered by previous work showing that infants' early social preferences are more likely to be driven by language than by race (Kinzler, Dupoux, & Spelke, 2012).

4 | GENERAL DISCUSSION

In the present set of studies, we demonstrated that already by 11 months of age, infants can learn the relation between language and ethnicity. Specifically, 11-month-old English-learning infants looked more to Asian versus Caucasian faces when paired with Cantonese versus when paired with English. Interestingly, infants at the same

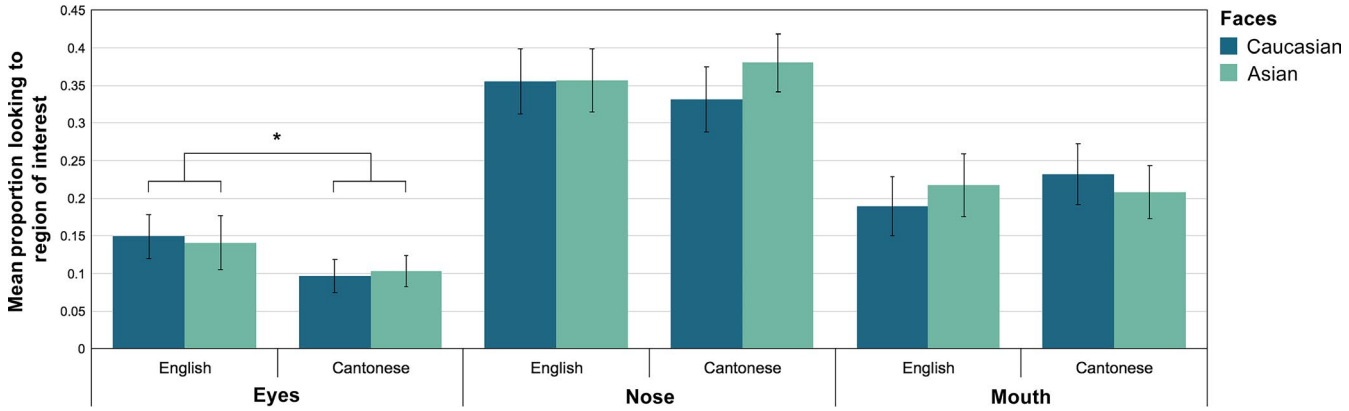


FIGURE 7 Infants' looking to regions of interest (eyes, nose, mouth) on Caucasian and Asian faces, for the combined sample of 11-month-old infants (N = 32) from Studies 1 and 3. Across both English and Cantonese trials, infants made a greater proportion of fixation to the nose versus eyes ($p < 0.001$) and mouth regions ($p = 0.016$). Infants made a greater proportion of fixations to eyes regions when hearing English versus Cantonese ($p = 0.011$)

age did not look more to Asian versus Caucasian faces when paired with Spanish, another unfamiliar language, making it unlikely that they have simply expected any unfamiliar language to pair with unfamiliar faces. Given that the infants tested in the current studies were raised in a metropolitan area with a sizeable Cantonese-speaking Asian population, this pattern of results is most parsimoniously explained by infants having learned a specific language-ethnicity association based on those individuals they have encountered in their environment. Parents in the current set of studies reported that their infants were exposed to Asian individuals, on average, 5%–12% of the time. While this estimation may seem low, it is important to note that this includes exposure to all individuals across all times—including that to parents and primary caregivers. Given that the day-to-day life of a young infant likely involves most exposure to those individuals within their own family (particularly for infants not in child-care, as is common for infants under 12 months in the country of testing), exposure to other-race Asian individuals for 5%–12% of the time may be significant. Additionally, such exposure may be to different individuals on different days and at different times, thus allowing ample opportunities for the infants to learn the pairing between Asian and Cantonese.

Three other pieces of evidence support the interpretation of a learned association between Cantonese and Asian individuals as exhibited by the infants tested. First, only 11-month-old and not 6-month-old infants showed evidence of this pairing, suggesting that infants may need to accumulate exposure to Cantonese and/or Asian individuals in order to form a connection between a language and ethnicity. Second, we found a nonsignificant trend such that infants whose parents reported regular exposure to one or more significant non-Caucasian individuals in their life more robustly showed differential looking to Caucasian and Asian faces when paired with Cantonese versus English than did infants whose parents reported no regular exposure. Taken together, these results suggest that between 6 and 11 months of age, infants raised in an environment in which they have even casual exposure to Cantonese-speaking Asian individuals come to detect a relationship between the language and ethnicity, with some suggestion (albeit marginal) that more consistent experience strengthens learning. Finally, English-learning infants of 11 months did not look longer to the Asian faces when hearing Spanish, thus ruling out the possibility that they were simply pairing any non-familiar language with faces of an ethnicity other than their own.

One note for the present studies is that only infants raised in a community with a sizeable multicultural population were tested. As such, all the infants were likely to have had at least some minimal exposure to non-Caucasian individuals and non-English languages. Moreover, a sizeable minority of such individuals in this community are Asian Cantonese speakers. It will be important for future research to extend this work to other communities, including those in which infants have very little exposure to other ethnicities and languages and/or significantly more exposure (i.e., Ellis et al., 2017; Singarajah et al., 2017). Based on the present findings, it might be predicted that infants' associations between ethnicity and language would differ based on the exposure to other-race and non-native language speakers in their communities.

The question of *how* infants come to learn a specific association between ethnicity and language remains unanswered. One possibility is that infants use simple associative mechanisms to pair together commonly experienced features of a given ethnicity (i.e., facial structure) and a given language (i.e., rhythmic features and/or phonemes). Given that young infants appear able to use cross-situational associations between visual and auditory information to guide their learning of word-object pairings (Smith & Yu, 2008), a similar mechanism could perhaps underlie their learning of language-ethnicity relationships. Alternatively, infants may be forming a more abstract understanding, building multimodal expectations of "Asian" versus "Caucasian" individuals that include both language and facial features. While the present research does not speak to these possibilities, future studies examining infants' abilities to rapidly learn novel language-ethnicity pairings through simple passive exposure, cross-situational contexts, and/or when word-learning or some other active use of language is necessary, and may help to determine the mechanisms by which infants associate these cues.

The finding that infants at 11 months of age can learn the link between ethnicity and language is also of interest because such learning may provide the foundation from which infants learn the dialects or languages of their native community. A recently published study indicates that by 16 months of age, toddlers expect individuals of their own ethnicity to speak their language with a familiar accent, but are willing to accept accented speech from individuals of another ethnicity (Weatherhead & White, 2018). In particular, when Caucasian English-learning infants were first shown an image of a woman of their own race, and then presented with either a correctly pronounced word or one with a shifted vowel, the infants only looked to the target image in a pair of images if the word was pronounced with their native accent. However, if first shown an image of a woman of a different race, the infants accepted a mispronunciation of the word as an acceptable label, and looked to the target image regardless of accent. Thus, by 16 months, it appears that infants can use their knowledge of the link between language and race to guide expectations about the acceptance of accented speech.

More recently, it has been shown ethnicity in the face might even influence language processing in infants as young as those tested in the current study, at least among bilingual-learning infants. Bilingual English-Chinese infants aged 10-months were first shown either a set of three Asian faces or a set of three Caucasian faces, and then tested on their ability to discriminate either an English-only (non-Chinese) speech sound difference/va/-/fa/, or a Chinese only (non-English) speech sound difference/tsa/-/ts^{h}a/. While there was no effect on discrimination of the English-only distinction, only those bilingual infants first primed with Asian faces subsequently discriminated the Chinese speech sound difference (Hu, Campbell, Danielson, & Werker, under review). Thus, it appears that the ability to learn the link between ethnicity and race, as shown in the current study, has functional consequences for language processing, perhaps even at the time that such a link is first being established.

ACKNOWLEDGMENTS

This research was supported by the Social Sciences and Humanities Research Council of Canada (grant 435-2014-0917 to JFW) and by the University of British Columbia (graduate student fellowships to LAM). The authors extend thanks to Dr. Drew Weatherhead for her comments and insights on an earlier version of this work, and to Savannah Nijeboer for creating the figures and editing the manuscript.

ORCID

Janet F. Werker https://orcid.org/0000-0002-1168-9013

REFERENCES

Bahrick, L. E., Hernandez-Reif, M., & Flom, R. (2005). The development of infant learning about specific face-voice relations. *Developmental Psychology*, *41*(3), 541–552. https://doi.org/10.1037/0012-1649.41.3.541

Bahrick, L. E., Netto, D., & Hernandez-Reif, M. (1998). Intermodal perception of adult and child faces and voices by infants. *Child Development*, *69*(5), 1263–1275. https://doi.org/10.2307/1132264

Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science*, *17*(2), 159–163. https://doi.org/10.1111/j.1467-9280.2006.01679.x

Bosch, L., & Sebastián-Gallés, N. (1997). Native-language recognition abilities in 4-month-old infants from monolingual and bilingual environments. *Cognition*, *65*(1), 33–69. https://doi.org/10.1016/S0010-0277(97)00040-1

Byers-Heinlein, K., Burns, T. C., & Werker, J. F. (2010). The roots of bilingualism in newborns. *Psychological Science*, *21*(3), 343–348. https://doi.org/10.1177/0956797609360758

Danielson, D. K., Bruderer, A. G., Kandhadai, P., Vatikiotis-Bateson, E., & Werker, J. F. (2017). The organization and reorganization of audiovisual speech perception in the first year of life. *Cognitive Development*, *42*, 37–48. https://doi.org/10.1016/j.cogdev.2017.02.004

Dehaene-Lambertz, G., Dehaene, S., & Hertz-Pannier, L. (2002). Functional neuroimaging of speech perception in infants. *Science*, *298*(5600), 2013–2015. https://doi.org/10.1126/science.1077066

Ellis, A. E., Xiao, N. G., Lee, K., & Oakes, L. M. (2017). Scanning of own- versus other-race faces in infants from racially diverse or homogenous communities. *Developmental Psychobiology*, *59*(5), 613–627. https://doi.org/10.1002/dev.21527

Fassbender, I., Teubert, M., & Lohaus, A. (2016). The development of preferences for own-race versus other-race faces in 3-, 6-and 9-month-old Caucasian infants. *European Journal of Developmental Psychology*, *13*(1), 152–165. https://doi.org/10.1080/17405629.2015.1073585

Hillairet de Boisferon, A., Dupierrix, E., Quinn, P. C., Lœvenbruck, H., Lewkowicz, D. J., Lee, K., & Pascalis, O. (2015). Perception of multisensory gender coherence in 6-and 9-month-old infants. *Infancy*, *20*(6), 661–674.

Hirschfeld, L. A., & Gelman, S. A. (1997). What young children think about the relationship between language variation and social difference. *Cognitive Development*, *12*(2), 213–238. https://doi.org/10.1016/S0885-2014(97)90014-9

Hu, S., Campbell, J., Danielson, D. K., & Werker, J. F. (under review). It depends who's talking: Contextual priming influences speech perception in Chinese-English bilingual infants.

Johnson, E. K., Westrek, E., Nazzi, T., & Cutler, A. (2011). Infant ability to tell voices apart rests on language experience. *Developmental Science*, *14*(5), 1002–1011. https://doi.org/10.1111/j.1467-7687.2011.01052.x

Kelly, D. J., Quinn, P. C., Slater, A. M., Lee, K., Gibson, A., Smith, M., … Pascalis, O. (2005). Three-month-olds, but not newborns, prefer own-race faces. *Developmental Science*, *8*(6), F31–F36. https://doi.org/10.1111/j.1467-7687.2005.0434a.x

Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2007). The native language of social cognition. *Proceedings of the National Academy of Sciences*, *104*(30), 12577–12580. https://doi.org/10.1073/pnas.0705345104

Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2012). 'Native' objects and collaborators: Infants' object choices and acts of giving reflect favor for native over foreign speakers. *Journal of Cognition and Development*, *13*(1), 67–81. https://doi.org/10.1080/15248372.2011.567200

Kubicek, C., De Boisferon, A. H., Dupierrix, E., Lœvenbruck, H., Gervain, J., & Schwarzer, G. (2013). Face-scanning behavior to silently-talking faces in 12-month-old infants: The impact of pre-exposed auditory speech. *International Journal of Behavioral Development*, *37*(2), 106–110. https://doi.org/10.1177/0165025412473016

Kuhl, P. K., & Meltzoff, A. N. (1982). The bimodal perception of speech in infancy. *Science*, *218*, 1138–1141. https://doi.org/10.1126/science.7146899

Lewkowicz, D. J., & Hansen-Tift, A. M. (2012). Infants deploy selective attention to the mouth of a talking face when learning speech. *Proceedings of the National Academy of Sciences*, *109*(5), 1431–1436. https://doi.org/10.1073/pnas.1114783109

Liu, S., Xiao, W. S., Xiao, N. G., Quinn, P. C., Zhang, Y., Chen, H., … Lee, K. (2015). Development of visual preference for own- versus other-race faces in infancy. *Developmental Psychology*, *51*(4), 500. https://doi.org/10.1037/a0038835

May, L., Byers-Heinlein, K., Gervain, J., & Werker, J. F. (2011). Language and the newborn brain: Does prenatal language experience shape the neonate neural response to speech? *Frontiers in Language Sciences*, *2*(222), 1–9.

May, L., Gervain, J., Carreiras, M., & Werker, J. F. (2018). The specificity of the neural response to speech at birth. *Developmental Science*, *21*(3), e12564–e12564. https://doi.org/10.1111/desc.12564

Mehler, J., Jusczyk, P., Lambertz, G., Halsted, N., Bertoncini, J., & Amiel-Tison, C. (1988). A precursor of language acquisition in young infants. *Cognition*, *29*(2), 143–178. https://doi.org/10.1016/0010-0277(88)90035-2

Minagawa-Kawai, Y., van der Lely, H., Ramus, F., Sato, Y., Mazuka, R., & Dupoux, E. (2010). Optical brain imaging reveals general auditory and language-specific processing in early infant development. *Cerebral Cortex*, *21*(2), 254–261. https://doi.org/10.1093/cercor/bhq082

Molnar, M., Gervain, J., & Carreiras, M. (2014). Within-rhythm class native language discrimination abilities of Basque-Spanish monolingual and bilingual infants at 3.5 months of age. *Infancy*, *19*(3), 326–337. https://doi.org/10.1111/infa.12041

Nazzi, T., Bertoncini, J., & Mehler, J. (1998). Language discrimination by newborns: Toward an understanding of the role of rhythm. *Journal of Experimental Psychology: Human Perception and Performance*, *24*(3), 756–766.

Nazzi, T., Jusczyk, P. W., & Johnson, E. K. (2000). Language discrimination by English-learning 5-month-olds: Effects of rhythm and familiarity. *Journal of Memory and Language*, *43*(1), 1–19. https://doi.org/10.1006/jmla.2000.2698

Patterson, M. L., & Werker, J. F. (2003). Two-month-old infants match phonetic information in lips and voice. *Developmental Science*, *6*(2), 191–196. https://doi.org/10.1111/1467-7687.00271

Pena, M., Maki, A., Kovacic, D., Dehaene-Lambertz, G., Koizumi, H., Bouquet, F., & Mehler, J. (2003). Sounds and silence: An optical topography study of language recognition at birth. *Proceedings of the National Academy of Sciences*, *100*(20), 11702–11705. https://doi.org/10.1073/pnas.1934290100

Pons, F., Lewkowicz, D. J., Soto-Faraco, S., & Sebastián-Gallés, N. (2009). Narrowing of intersensory speech perception in infancy. *Proceedings of the National Academy of Science*, *106*(26), 10598–10602. https://doi.org/10.1073/pnas.0904134106

Poulin-Dubois, D., Serbin, L. A., Kenyon, B., & Derbyshire, A. (1994). Infants' intermodal knowledge about gender. *Developmental Psychology*, *30*, 436–442. https://doi.org/10.1037/0012-1649.30.3.436

Ramus, F., Hauser, M. D., Miller, C., Morris, D., & Mehler, J. (2000). Language discrimination by human newborns and by cotton-top tamarin monkeys. *Science*, *288*(5464), 349–351. https://doi.org/10.1126/science.288.5464.349

Richoz, A.-R., Quinn, P. C., Hillairet de Boisferon, A., Berger, C., Loevenbruck, H., Lewkowicz, D. J., … Pascalis, O. (2017). Audio-visual perception of gender by infants emerges earlier for adult-directed speech. *PLoS ONE*, *12*(1), e0169325. https://doi.org/10.1371/journal.pone.0169325

Sato, H., Hirabayashi, Y., Tsubokura, H., Kanai, M., Ashida, T., Konishi, I., … Maki, A. (2012). Cerebral hemodynamics in newborn infants exposed to speech sounds: A whole-head optical topography study. *Human Brain Mapping*, *33*(9), 2092–2103. https://doi.org/10.1002/hbm.21350

Sebastián-Gallés, N., Albareda-Castellot, B., Weikum, W., & Werker, J. F. (2012). A bilingual advantage in visual language discrimination in infancy. *Psychological Science*, *23*(9), 994–999. https://doi.org/10.1177/0956797612436817

Singarajah, A., Chanley, J., Gutierrez, Y., Cordon, Y., Nguyen, B., Burakowski, L., & Johnson, S. P. (2017). Infant attention to same-and other-race faces. *Cognition*, *159*, 76–84. https://doi.org/10.1016/j.cognition.2016.11.006

Smith, L., & Yu, C. (2008). Infants rapidly learn word-referent mappings via cross-situational statistics. *Cognition*, *106*(3), 1558–1568. https://doi.org/10.1016/j.cognition.2007.06.010

Statistics Canada. (2016). Vancouver [Census metropolitan area], British Columbia and British Columbia [Province] (table). Census Profile, 2016 Census (Statistics Canada Catalogue no. 98-316-X2016001). Ottawa, Ontario. Released November 29, 2017.

Uttley, L., De Boisferon, A. H., Dupierrix, E., Lee, K., Quinn, P. C., Slater, A. M., & Pascalis, O. (2013). Six-month-old infants match other-race faces with a non-native language. *International Journal of Behavioral Development*, *37*(2), 84–89. https://doi.org/10.1177/0165025412467583

Vannasing, P., Florea, O., González-Frankenberger, B., Tremblay, J., Paquette, N., Safi, D., … Gallagher, A. (2016). Distinct hemispheric specializations for native and non-native languages in one-day-old newborns identified by fNIRS. *Neuropsychologia*, *84*, 63–69. https://doi.org/10.1016/j.neuropsychologia.2016.01.038

Vouloumanos, A., Druhen, M. J., Hauser, M. D., & Huizink, A. T. (2009). Five-month-old infants' identification of the sources of vocalizations. *Proceedings of the National Academy of Sciences*, *106*(44), 18867–18872. https://doi.org/10.1073/pnas.0906049106

Vouloumanos, A., & Werker, J. F. (2007). Listening to language at birth: Evidence for a bias for speech in neonates. *Developmental Science*, *10*(2), 159–164. https://doi.org/10.1111/j.1467-7687.2007.00549.x

Walker-Andrews, A. S., Bahrick, L. E., Raglioni, S. S., & Diaz, I. (1991). Infants' bimodal perception of gender. *Ecological Psychology*, *3*(2), 55–75. https://doi.org/10.1207/s15326969eco0302_1

Weatherhead, D., & White, K. S. (2018). And then I saw her race: Race-based expectations affect infants' word processing. *Cognition*, *177*, 87–97. https://doi.org/10.1016/j.cognition.2018.04.004

Weikum, W., Vouloumanos, A., Navarra, J., Soto-Faraco, S., Sebastián-Gallés, N., & Werker, J. F. (2007). Visual language discrimination in infancy. *Science*, *316*(5828), 1159. https://doi.org/10.1126/science.1137686

Wheeler, A., Anzures, G., Quinn, P. C., Pascalis, O., Omrin, D. S., & Lee, K. (2011). Caucasian infants scan own-and other-race faces differently. *PloS one*, *6*(4), e18621.

Xiao, N. G., Quinn, P. C., Liu, S., Ge, L., Pascalis, O., & Lee, K. (2015). Eye tracking reveals a crucial role for facial motion in recognition of faces by infants. *Developmental Psychology*, *51*(6), 744. https://doi.org/10.1037/dev0000019

Xiao, W. S., Xiao, N. G., Quinn, P. C., Anzures, G., & Lee, K. (2013). Development of face scanning for own- and other-race faces in infancy. *International Journal of Behavioral Development*, *37*, 100–105. https://doi.org/10.1177/0165025412467584

How to cite this article: May L, Baron AS, Werker JF. Who can speak that language? Eleven-month-old infants have language-dependent expectations regarding speaker ethnicity. *Developmental Psychobiology*. 2019;61:859–873. https://doi.org/10.1002/dev.21851

APPENDIX A

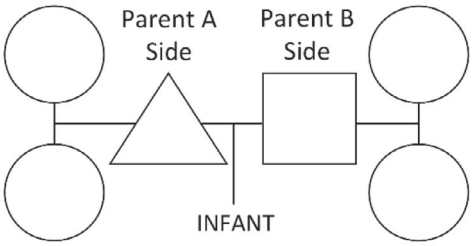
Language and Ethnicity Questionnaire

BABY ID:_____

DATE OF BIRTH: _____

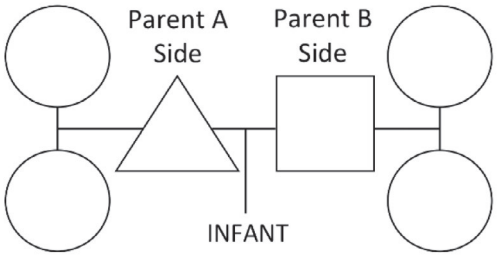
DATE OF EXPERIMENT: _____

LANGUAGES SPOKEN BY FAMILY:



NOTES:

ETHNICITY OF FAMILY MEMBERS:



NOTES:

TYPICAL DAY LENGTH: Wake up time: _____ Bed time: _____ Typical day length (max 24): _____

PARENTS/CARETAKERS (e.g., parents, grandparents, babysitters, etc.):
Who spends time with the baby and what language do they speak

Who?	Language spoken	Ethnicity	What ages?	More than 1 hr per week	Hours/week	Since when?

FAMILY (e.g., grandparents, siblings, aunt, uncles etc.):
Who spends time with the baby and what language do they speak

Who?	Language spoken	Ethnicity	What ages?	More than 1 hr per week	Hours/week	Since when?

VIDEO CONFERENCING/TV
Does the baby participate in video conferencing (e.g., Skype)? Y/N Watch TV? Y/N

Who/shows	Language	Ethnicity	What ages?	>1 hr a week	Hours/week	Since when?

FRIENDS

Who spends time with the baby and what language do they speak

Who?	Language spoken	Ethnicity	What ages?	More than 1 hr per week	Hours/week	Since when?

BABY GROUPS (play groups, story time, mom/baby classes, etc)

Do you attend baby groups?

Which?	Language spoken	Ethnicity	What ages?	More than 1 hr per week	Hours/week	Since when?

DAYCARE

Does your child attend daycare?

Since when?	Language spoken	Ethnicity of day care provider	Hours/week

NEIGHBORHOOD AND PUBLIC AREA

How often do you go outside with your baby?

Where?	Languages spoken	Ethnicity	Days/week	Hours/day	Since when?

TRAVEL

Has the child lived/vacationed in any country **where s/he would hear a language other than English?**

If yes, Where?_____

When?_____

And for how long?_____

TOTAL ESTIMATE: ..... % L1/ ..... % L2/ .....% other

..... % E1/..... % E2/.....% other