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Not All Gaze Cues Are the Same: Face Biases Influence Object Attention in Infancy

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NOT ALL GAZE CUES ARE THE SAME: FACE BIASES INFLUENCE OBJECT ATTENTION IN INFANCY

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by

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ABSTRACT

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MAY 2015

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In their first year, infants' ability to follow eye gaze to allocate attention shifts from being a response to low-level perceptual cues, to a deeper understanding of social intent. By 4 months infants look longer to uncued versus cued targets following a gaze cuing event, suggesting that infants better encode targets cued by shifts in eye gaze compared to targets not cued by eye gaze. From 6 to 9 months of age infants develop biases in face processing such that they show increased differentiation of faces within highly familiar groups (e.g., own-race) and a decreased differentiation of faces within unfamiliar or infrequently experienced groups (e.g., other-race). Although the development of cued object learning and face biases are both important social processes, they have primarily been studied independently. The current study examined whether early face processing biases for familiar compared to unfamiliar groups influences object encoding within the context of a gaze-cuing paradigm. Five- and 10-month-old infants viewed videos of adults, who varied by race and sex, shift their eye gaze towards one of two objects. The two objects were then presented side-by-side and fixation duration for the cued and uncued object was measured. Results revealed 5-month-old infants look significantly longer to uncued versus cued objects when the cuing face was a female.

Additionally, 10-month-old infants displayed significantly longer looking to the uncued relative to the cued object when the cuing face was a female and from the infant's own-race group. These findings are the first to demonstrate that perceptual narrowing based on sex and race shape infants' use of social cues for allocating visual attention to objects in their environment.

TABLE OF CONTENTS

Page

ABSTRACT....................iii

LIST OF TABLES....................vii

LIST OF FIGURES....................viii

CHAPTER

1. INTRODUCTION....................1

Developmental Trajectory of Eye Gaze Following & Cued Object Learning.........2

Developmental Trajectory of Face Biases....................5

Face Processing Biases & Social Cue Perception....................9

Current Study....................10

2. METHODS....................12

Participants....................12

Stimuli....................13

Video stimuli development....................13

Object stimuli development....................14

Eye-tracking Apparatus and Data Collection Details....................15

Procedure....................16

Data analyses....................18

3. RESULTS....................20

Questionnaire data....................20

Gaze-Cuing Phase....................20

Duration of looking....................20

Location of first object fixation..21
Object Comparison Test Trial..21
5-month-old infants..22
10-month-old infants..22
4. DISCUSSION..23
Conclusions..29
APPENDICES
A. IN-DEPTH DEMOGRAPHIC QUESTIONNAIRE..36
B. FACE AND OBJECT DURATION OF LOOKING DURING GAZE-CUING PHASE..38
C. PROPORTION OF FIRST FIXATIONS MADE TO CUED OBJECT DURING GAZE-CUING PHASE..42
REFERENCES..45

LIST OF TABLES

Table Page

1. Infants’ Frequent Social Experiences..30

LIST OF FIGURES

Figure Page

1. Examples of cuing face videos and object stimuli…………………...………..31

2. Experimental eye-tracking apparatus set-up……………….........…………..32

3. Experimental paradigm trial………………..............……….………….…...33

4. Results from separate paired sample t-tests comparing average looking duration to the cued versus uncued object during the first test trial......…..………..........34

5. Results from separate paired sample t-tests comparing average looking duration to the cued versus uncued object.……..................……......…………………….35

CHAPTER 1

INTRODUCTION

Our eyes are central to receiving and expressing social cues. Using social cues to individuate faces, process facial emotions, and follow shifts in eye gaze have been shown to be influenced by early and frequent social experiences infants have during their first year of life (for reviews see Grossmann & Johnson, 2007; Moore & Corkum, 1994; Striano & Reid, 2006). For example, it is hypothesized that biases in face processing begin with infants learning to better discriminate between individual faces from within highly familiar groups (e.g., own-race) and categorize or group together faces from infrequently experienced groups (e.g., other-race; for reviews see Lee, Anzures, Quinn, Pascalis, & Slater, 2011, Chapter 39; Scherf & Scott, 2012; Scott, Pascalis, & Nelson, 2007). During a similar period infants also learn how to use face and eye-gaze information to orient their attention toward objects, events, and people within their environment (for reviews see Frischen, Bayliss, & Tipper, 2007; Striano & Reid, 2006). For adults, efficiently using social cues of attention varies based on perceived characteristics, such as social group membership (e.g., race) of a face (Dalmaso, Pavan, Castelli, & Galfano, 2011; Pavan, Dalmaso, Galfano, & Castelli, 2011). However it is unclear if, like adults, social group membership of faces affects infants' attention and subsequent object learning from shifts in eye gaze. The current study examined whether the development of face processing biases across sex and race influenced infants' object learning from shifts in eye gaze orientation.

Developmental Trajectory of Eye Gaze Following & Cued Object Learning

From birth, infants show sensitivity to faces and eye gaze orientation. For example, neonates look longer towards faces with open eyes versus closed or averted eyes (Batki, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000; Farroni, Csibra, Simion, & Johnson, 2002). Additionally, neonates display an ability to follow shifts in eye gaze orientation. For example, Farroni and colleagues (2004) presented schematic faces to 1- to 5-day-old infants and measured faster saccades to cued compared to uncued targets, but only when eye motion information was presented. Early in development attention to shifts in eye gaze has been hypothesized to be a result of sensitivity to the low-level perceptual cue of lateralized movement of the eyes (Farroni, Johnson, Brockbank, & Simion, 2000; Farroni, Massaccesi, Pividori, & Johnson, 2004; Hood, Willen, & Driver, 1998). Infants later develop a deeper understanding of social partnership and intent when seeing gaze cuing events (Cleveland, Schug, & Striano, 2007; Csibra & Volein, 2008; Deligianni, Senju, Gergely, & Csibra, 2011; Hoehl, Michel, Reid, Parise, & Striano, 2014; Johnson, Ok, & Luo, 2007; Okumura, Kanakogi, Kanda, Ishiguro, & Itakura, 2013a; Senju, Csibra, & Johnson, 2008; Senju, Johnson, & Csibra, 2006). Between 3 and 5 months infants begin to reliably shift their attention in the direction of an adults' eye gaze towards a cued target (D'Entremont, Hains, & Muir, 1997; D'Entremont, 2000; Gredebäck, Fikke, & Melinder, 2010; Gredebäck, Theuring, Hauf, & Kenward, 2008) and display faster saccadic reaction time to cued versus uncued objects (Farroni et al., 2000; Hood et al., 1998; Theuring, Gredebäck, & Hauf, 2007). At 4 months, infants also show greater neural responses to shifts in another's eye gaze which accurately versus inaccurately cue objects (Hoehl, Reid, Mooney, & Striano, 2008). In sum, these results indicate infants learn to use eye gaze to direct their attention towards external events resulting in greater processing of cued targets.

Previous reports indicate that enhanced processing of gaze-cued targets is reflected by longer looking to the *uncued* versus cued object during a visual comparison task (Cleveland et al., 2007; Hoehl, Wahl, & Pauen, 2013; Okumura, Kanakogi, Kanda, Ishiguro, & Itakura, 2013b; Reid & Striano, 2005; Theuring et al., 2007; Wahl, Michel, Pauen, & Hoehl, 2012). Longer looking to the uncued object is reliably displayed by 4 months of age and suggests that infants interpret the uncued object as more novel than the cued object (Hoehl et al., 2013; Reid & Striano, 2005; Wahl et al., 2012). Enhanced cued object processing and longer looking to the uncued object has also been found to be sensitive to the type of social agent displaying cues. For example, infants display longer looking to the uncued object after seeing human gaze shifts, but not for non-human agents such as cars (Wahl et al., 2012) and robots (Okumura et al., 2013b). Gaze cuing and object processing have also been examined using event-related potentials (ERPs). ERPs are a noninvasive measure of neural activity in response to the presentation of time-locked events, such as the presentation of an object or face (Luck, 2005). Studies have reported greater neural activity associated with working memory updating or encoding (Hoehl, Wahl, Michel, & Striano, 2012; Reid, Striano, Kaufman, & Johnson, 2004) and attention (Hoehl et al., 2013; Wahl et al., 2012) for uncued versus cued objects. Findings from looking duration and ERP research demonstrate that infants use shifts in adult eye gaze to direct attention resulting in increased familiarization with cued objects or events.

One model to account for eye gaze following and object processing in infancy is the directed attention model (Hoehl et al., 2009; Reid & Striano, 2007). This model proposes five stages that infants complete to successfully filter out irrelevant environmental events and follow shifts of visual attention. Specifically, infants first detect a relevant social agent, second they identify this agent (e.g., a face's individual identity), third infants assess the agent's attention orientation relative to themselves, fourth locate external objects the agent is focused on, and fifth infants prepare a response to and subsequently learn from shifts in eye gaze (Hoehl et al., 2009; Reid & Striano, 2007). The directed attention model hypothesizes that a familiar face will be more efficiently identified than an unfamiliar face; resulting in quicker detection of eye gaze towards an external target (i.e., the fourth stage) and better encoding of cued targets (Hoehl et al., 2009; Reid & Striano, 2007). Recent ERP research supports this hypothesis with evidence that 4-month-old infants showed increased ERP amplitude for uncued objects versus cued objects after seeing eye-gaze cues from their primary caregiver compared to a stranger (Hoehl et al., 2012). Hoehl and colleagues (2012) suggest that their findings may be driven by infants more readily identifying a familiar face, resulting in facilitated cued object processing. The directed attention model provides a framework for investigating the development of eye gaze following, however it remains unclear whether seeing gaze shifts in highly experienced or familiar groups of people (e.g., sex, own-race) results in better cued object processing, relative to seeing gaze shifts in people from infrequently experienced face categories (e.g., other-race).

Limited work with adults has found that categorization of faces based on perceived group membership influences gaze following efficiency (Dalmaso et al., 2011; Pavan et al., 2011). For example, Pavan and colleagues (2011) found that White-Italian adults exhibited faster reaction times to visual objects when cued by White faces compared to Black faces, suggesting an own-race bias for eye-gaze following (Pavan et al., 2011). The own-race bias was not found for Black-Italian participants, Black-Italians exhibited faster reaction times to congruent shifts in eye gaze for both White and Black faces (Pavan et al., 2011). The authors interpreted these findings as evidence that race categorization moderates adults' response time to shifts of attention. Taken together with recent infant ERP research characteristics of a face, such as perceived race (Pavan et al., 2011) or personal familiarity (Hoehl et al., 2012), influence responses to cues of visual attention. The emergence of face processing biases during infancy may lend to further understanding how face categorization influences social learning.

Developmental Trajectory of Face Biases

To date, no studies have examined the influence of face biases on eye gaze following in the context of object learning during development. However, researchers have examined the development of face processing biases within the first year of life (for reviews see Pascalis et al., 2011; Scherf & Scott, 2012; Scott, Pascalis, & Nelson, 2007). From 3 to 9 months of age, infants become tuned to faces that are most relevant in their environment resulting in enhanced face processing abilities and a decline or delayed development for unfamiliar face groups (for review see: Pascalis et al., 2011; Ramsey et al., 2005; Scherf & Scott, 2012; Scott et al., 2007). This developmental effect, known as perceptual narrowing or perceptual tuning, is a result of the frequency as well as type of perceptual experiences infants have in their first year (Di Giorgio, Meary, Pascalis, & Simion, 2012; Kelly et al., 2009; Kelly, Liu, et al., 2007; Kelly, Quinn, et al., 2007; Pascalis et al., 2005, 2002; Rennels & Davis, 2008). Previous research has found that infants primarily interact with adults of the same race, sex, and age as their primary caregiver and suggest that these differential experiences likely shapes face processing biases (Rennels & Davis, 2008; Sugden, Mohamed-Ali, & Moulson, 2014).

Perceptual biases for either male or female faces begins early in infancy and has been found to be driven by the sex of infants' primary caregiver (for review see Ramsey et al., 2005). For example, 3-month-old infants display longer spontaneous looking towards faces that are the same sex (Hillairet de Boisferon, Uttley, Quinn, Lee, & Pascalis, 2014; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002) as well as race (Quinn et al., 2008) as their primary caregivers. Beyond spontaneous preferences, neonates have been found to discriminate between their mother's face and a female stranger's face (Bushneil, Sai, & Mullin, 1989; Field, Cohen, Garcia, & Greenberg, 1984; Pascalis & Schonen, 1995; Walton, Bower, & Bower, 1992). No such discrimination ability is found for father's faces at birth (Walton et al., 1992) or by 4 months of age (Ward, 1998). Moreover, infants whose primary caregiver is female demonstrate increased differentiation of female faces relative to male faces (Barrera & Maurer, 1981; Quinn et al., 2002). The ability to differentiate between two similar looking male faces is not reliably demonstrated until 7 months of age (Fagan, 1976; Righi, Westerlund, Congdon, Troller-Renfree, & Nelson, 2014). Recent ERP and eye-tracking findings suggest 7-month-old infants who were reported to spend equal to or greater than 70% of their social interactions with females were found to have a greater N290 amplitude to female faces compared to male faces as well as for novel female faces compared familiarized female faces (Righi et al., 2014). The N290 is believed to be a face-sensitive component that has been measured in infants as early as 3 months of age (Halit, Csibra, Volein, & Johnson, 2004). These findings suggest that although infants learn to differentiate between male faces, early social experiences bias infants' face processing toward female faces when the primary caregiver is female. Specifically, infants display early and lasting expertise for female faces with later developing face expertise for male faces.

Perceptual narrowing has also been found to increase infants' ability to differentiate faces within highly familiar groups (e.g., own-race), and decrease differentiation for faces within unfamiliar or infrequently experienced groups from 5 to 9 months of age (e.g., other-race, other-species; Anzures, Pascalis, Quinn, Slater, & Lee, 2011; Di Giorgio et al., 2012; Kelly et al., 2005; Kelly, Liu, et al., 2007; Kelly, Quinn, et al., 2007; Pascalis et al., 2005, 2002; Spangler et al., 2012; Vogel, Monesson, & Scott, 2012). The other-race effect is an example of a perceptual narrowing outcome. Three- and 4-month-olds, but not neonates display spontaneous longer looking toward faces within the race infants have the most experience with (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005). Although 3-month-old infants display preferential looking to familiar race faces, they remain reliably able to differentiate between two faces within both familiar and unfamiliar races (Kelly, Liu, et al., 2007; Kelly, Quinn, et al., 2007). However using a visual paired comparison task, by 6 months of age infants' ability to differentiate other-race faces declines and by 9 months, infants only differentiate among faces within the racial group they have had the most experience with (i.e., typically own-race; Kelly et al., 2009; Kelly, Quinn, et al., 2007; Vogel et al., 2012). These results suggest that infants shape their perceptual systems in response to faces they frequently experience within their environment.

Perceptual narrowing is further supported by recent eye-tracking research that has examined how infants scan own- and other-race faces. Between 4 and 9 months of age several studies have found either maintained or increased looking duration to the upper-half (e.g., eyes or nose) of own-race, but not other-race faces (Liu et al., 2011; Wheeler et al., 2011; Xiao, Quinn, Pascalis, & Lee, 2014; Xiao, Xiao, Quinn, Anzures, & Lee, 2013). These changes in visual scan patterns are hypothesized to underline the increase in individuation of own-race faces and decline in individuation of other-race faces (Liu et al., 2011). However, with increased exposure during testing (Fair, Flom, Jones, & Martin, 2012; Sangrigoli & de Schonen, 2004) and individual-level label training (Anzures et al., 2012; Heron-Delaney et al., 2011; Pascalis et al., 2005; Scott & Monesson, 2009), 9-month-old infants exhibited differentiation of faces within unfamiliar face groups. Bar-Haim and colleagues (2006) find own-race face preferences are not present for infants raised in a racially diverse environment. Taken together, these findings indicate that face processing systems can remain flexible based on the type and amount of experiences an infant has with particular groups.

Robust effects of perceptual narrowing have been found to extend beyond face discrimination and into areas of learning (Fassbender et al., 2012, 2014). In cross-cultural longitudinal studies, Fassbender and colleagues (2012; 2014) found that that at 3 months infants learned a spatial location pattern with own- and other-race female faces, but by 6 months infants only learned the pattern when presented with own-race female faces. These findings indicate that perceptual narrowing outcomes are displayed within the context of learning new tasks. Due to the wealth of social information available to infants when perceiving a face it is likely that perceptual narrowing for own-race and females also extend to processing socially relevant facial cues. Specifically, perceptual narrowing may in turn facilitate infant's ability to identify and learn from a social partner within a familiar group and decline for unfamiliar face groups. Limited research has examined how the robust effects of these biases for differentiating faces extends to changes in infants' social information processing.

Face Processing Biases & Social Cue Perception

Perceptual tuning for own-race and female faces has been found to influence infants' ability to match face-voice associations (Poulin-Dubois, Serbin, Kenyon, & Derbyshire, 1994; Poulin-Dubois, Serbin, Derbyshire, 1998; Vogel et al., 2012). For example, by 9 months of age infants reliably match female faces with female voices, but do not match male faces with male voices until 18 months of age (Poulin-Dubois et al., 1998; Poulin-Dubois et al., 1994). However, other studies have found that by 6 to 8 months, infants can reliable match both male and female faces with gender-congruent voices (Patterson & Werker, 2002; Walker-Andrews, Bahrick, Raglioni, Diaz, 1991). Thus further work is needed to better understand the developmental trajectory for matching male faces and voices.

In another investigation, Vogel and colleagues (2012) recorded ERPs while 5- and 9-month-old Caucasian infants heard an emotion sound (e.g., laughing and crying) followed by seeing either a congruent or incongruent emotion face (e.g., happy or sad). Emotion faces were adult females from the same- (i.e., Caucasian) or other- (i.e., African-American) race group as the infant (Vogel et al., 2012). Vogel and colleagues (2012) found that 5-month-old, but not 9-month-old, Caucasian infants showed no differential neural processing of emotion sound-face pairs for own- compared to other-race faces. Nine-month-old Caucasian infants had race-specific neural responses including a larger perceptual response to own- versus other-race faces and differential processing of emotion sound-face congruency for own-race faces but not for other-race faces (Vogel et al., 2012). The results from this study suggests that perceptual narrowing leads to a decline in ability to match visual and vocal emotion information for other-race faces (Vogel et al., 2012). Given these previous findings demonstrating expertise for own-race and female faces, we investigated whether or not face biases increases infants' detection and learning from eye gaze for own- and female faces relative to other-race and male faces.

Current Study

Although the trajectory of face processing biases and the development of object learning from eye gaze is similar, to-date these areas of research have been separately investigated. Thus it remains unclear whether the development of face processing biases influence infants' object processing in the context of an eye-gaze cuing task. Previous research has shown that by 4 months of age infants look longer towards objects not previously cued by an adult face (Reid & Striano, 2005). Additionally, infants' encoding of cued versus uncued objects increased when the cuing face was their primary caregiver (Hoehl et al., 2012). Furthermore, between 3 and 9 months of age infants fine-tune their perceptual discrimination abilities for faces from groups frequently individuated and a decline for those face groups that are infrequently experienced (for reviews see Pascalis et al., 2011; Ramsey et al., 2005; Scherf & Scott, 2012; Scott et al., 2007). However studies have yet to examine whether the advantages for processing objects cued by a personally familiar face extend to familiarity with social groups and how this changes across the first year of life. The current study examined the development of object processing from gaze-cuing events during a time period in which perceptual face biases have been found to develop. Specifically, the current study investigated whether between 5 and 10 months of age perceptual narrowing for faces based on sex and race, influenced object encoding when infants saw adults shift their eye gaze to peripheral targets. The current study used eye-tracking to measure infants' looking duration during a gaze cuing and object comparison task. We analyzed if infants looked longer to the uncued versus cued object based on whether the cuing face was male or female as well as from infants' own- or other-race group. We predicted that at 5 months, infants would look longer to the uncued versus cued object when they previously saw female cuing faces regardless of race. In contrast we predicted that by 10 months of age, perceptual narrowing would be reflected by longer looking to the uncued compared to cued object when previously presented with own-race female cuing faces.

CHAPTER 2

METHODS

Five- and 10-month-old infants and their families came into the lab and completed an eye-gaze object cuing task while eye fixations were recorded with an eye-tracker. Prior to their visit, primary caregivers completed an in-depth questionnaire related to demographic information and experiences of their infant. All methods and procedures used in this study were reviewed and approved by the University of Massachusetts, Amherst Institutional Review Board.

Participants

The current study recruited 42 five-month-old and 27 ten-month-old infants. The final sample size included 23 five-month-olds (*M* = 160.87 days, *SD* = 4.72; 15 females) and 19 ten-month-olds (*M* = 307.11 days *SD* = 8.44; 11 females). Infants were excluded from the final sample if they exhibited a looking side bias (5m *n* = 5), failed to complete all 12 trials due to fussiness (5m *n* = 6, 10m *n* = 3), if there was a computer error (5m *n* = 5, 10m *n* = 1), or if their average looking duration during the first object test trial to both objects exceeded 2 SD above or below the mean (5m *n* =2, 10m *n* = 2). The current study examined whether seeing a face of a highly familiar (e.g., own-race) versus unfamiliar race influences infants' processing of cuing information, therefore we did not include infants who were identified by their primary caregivers as being multiracial or growing up in a primarily multiracial environment, as these infants have more than one own-race face group (5m *n* = 1, 10m *n* = 2).

The in-depth questionnaire had primary caregivers identify their infant's demographic information (e.g., race, biological sex) and describe the frequency of social experiences their infant had with males and females as well as people of same and different races (Appendix A). For example caregivers listed the race and gender of the five individuals that their infant had the most contact with on a weekly basis, this gave an idea of whom infants interacted with. Of the infants included in the final sample, 36 were racially identified as White or Caucasian, 2 as Asian, and 1 as American Indian/Alaskan Native White. One infant was ethnically identified as Hispanic or Latino. One parent who self-identified as White or Caucasian chose not to disclose their infant's racial or ethnic identity and two other parents did not complete the survey. All infants were typically developing with no history of neurological damage or of premature birth. Primary caregivers received $10.00 for participation and infants received a small toy.

Stimuli

Video stimuli development

Videos of adults laterally shifting their eyes were created for the face stimuli (Figure 1). Nineteen University of Massachusetts, Amherst students between the ages of 18 and 34 years were recorded and paid $5.00 for participation. Adults were self-identifying males or females from one of three racial categories: White/Caucasian, Black/African-American, or East-Asian/Asian-American. For all eye-tracking data analyses the race face category variable was coded as own-race, other-race 1, and other-race 2 relative to the infant's identified race (e.g., Caucasian faces coded as own-race for Caucasian infants). Videos were recorded with a *Canon Vixia HF R300 HD*, positioned approximately 50 inches away from seated adults. Adults' physical appearances were controlled by wearing the same black t-shirt, removing glasses or facial piercings, and having little to no facial hair. Onset time and speed of eye shifts were controlled by asking adults to track a rolling ball projected onto a wall using a Powerpoint presentation. Apple application *iMovie* (edition 6.0.3) was used to convert videos to grayscale and edited to 2 s in length. Face stimuli were sized to a visual angle width of 8.44° (8.2 cm) and height of 8.94° (8.68 cm). Five independent adults rated each video on friendliness and eye visibility using a 3-point likert scale. Videos with the two highest overall average scores for each race-sex face group were included in the final stimulus set resulting in 12 face videos. The average rating for the included face videos was 2.51 (SD = .21). The average ratings across race and sex were as follows: African-American females 2.59 (SD = 0.15), African-American males 2.7 (SD = 0.15), Asian females 2.5 (SD = 0.22), Asian males 2.4 (SD = 0.27), Caucasian females 2.4 (SD = 0.53), and Caucasian males 2.3 (SD = 0.41).

Object stimuli development

Twenty-four computer generated objects were used for the cued and uncued targets (Figure 1). Eight colors were randomly applied across objects using the graphic design program *Modo 601*. All objects were sized to be presented at a visual angle width of 10.14° (6.56 cm) and height of 7.1° (6.88 cm). Participants were randomly assigned to one of four counterbalance conditions. For each counterbalance condition objects were pseudo randomly paired together, with the restriction that objects with the same color and shape were not paired. Within each counterbalance condition object pairs were randomly assigned to 1 of 12 adult faces, with no object pairs being repeated. Lastly, no object pairs or face-object pairs were repeated across counterbalance conditions.

Eye-tracking Apparatus and Data Collection Details

An EyeLink 1000 arm mount eye-tracking system (SR Research Ltd, Mississauga, Ontario, CA) was used with a 16 mm lens, a 940 nm infrared illuminator, and a sampling rate of 500 Hz to record infants' eye movements (Figure 2). Infants saw face and object videos on a 17 inch LCD computer monitor. Allowable head movement for the eye-tracker without reducing tracking accuracy was approximately 22 cm (horizontally) x 18 cm (vertically) x 20 cm (depth). The arm mount gaze tracking range was approximately 32° horizontally and 25° vertically. An eye track was recovered within 3 ms (*SD* = 1.11 ms) of losing the track, however if data was missing due to excessive head movement, loss of head target sticker or eye-pupil target etc, it was recorded online as an eye blink. Eye blinks are recorded online, but are independent of fixations and therefore are not a source of error for analyzed fixation data.

Prior to starting the experiment each infant completed a triangular 3-point calibration measure repeating their first fixation (for a total of 4 fixations). Calibration maps participants' eye fixation information from standard target positions, which is then used to calculate gaze data during the recording session. Calibration points were randomly ordered to the top-center, left- and right-bottom corners of the computer screen (Figure 3). Calibration targets were brightly colored animated cartoons (e.g., Purple Square with smiley face), sized 100 x 100 pixels and were repeated until infants had fixated on each location resulting in a small equilateral triangle with the fourth fixation closely overlapping the first.

A heuristic filter was used during online data collection (for further details see Stampe, 1993). Heuristic filtering removes noise prior to the detection of saccades and fixations as well as reduces the frequency of false fixations being recorded in the output (Stampe, 1993). A saccade-pick algorithm was used to identify fixations, such that recorded eye samples (i.e., movements) that did not exceed the saccade thresholds were registered as fixations. Saccade thresholds included eye movements that exceeded a velocity of 30 degrees/second or an acceleration of 8,000 degrees/second squared, and was a movement of at least 15 degrees. Saccade recording ended once the velocity and acceleration of the eye movement dropped below the reported thresholds.

Each area of interest was a hand drawn rectangle approximately 30 pixels greater than the entire face or object image. The same area of interest was used for all adult faces (9.24° width x 9.74° height) and for the cued and uncued objects (10.08° width x 7.91° height).

Procedure

Infants completed 12 trials. Each trial included a video of a different face, which varied by race (i.e., Caucasian, African-American, or Asian) and sex, shift their eye-gaze towards the appearance of two brightly colored objects (Figure 3). A new pair of objects was presented during each trial. Infants were randomly assigned to 1 of 4 counterbalance conditions. Gaze cuing face presentation order and object pairs were randomized across the 4 counterbalance conditions. Infants sat in a highchair approximately 55 cm away from the eye-tracker with their caregivers seated behind them, out of their line of sight.

Trials began with an adult's face with direct gaze in the middle of the computer screen. Previous eye gaze studies have found that infants are less likely to follow an adult's shift in gaze without initial presentation of direct eye gaze to establish engagement with the infant (Senju et al., 2008). The gaze cuing phase began once infants fixated on the face for a minimum of 300 ms and adults' eyes laterally shifted to either the left or the right. Averted gaze was held for 2 s before two objects were simultaneously presented, one on either side of the face. This created an effect as if the adult's eye gaze cued the appearance of an object on the same side of the face. The object located on the congruent side of the eye gaze was the cued object and the object on the incongruent side was the uncued object. Objects remained on the screen with the adult's averted eye gaze until infants accumulated 1 s of looking towards the face or either objects.

Gaze direction and location of cued object during the cuing phase was presented in a semi-random order, with no more than two trials with the same direction occurring in a row. The race and sex of the adult faces were presented in a semi-random order such that one exemplar of each race-sex face category (e.g., Caucasian female) was presented in the first 6 trials. The individual adult from each race-sex category and order of face presentations were randomized across four counterbalances. Twenty instrumental songs (e.g., steel drums, melodies of nursery rhymes), were randomly played with the face and objects to help hold infants' interest.

Once infants accumulated 1 s of looking towards the face or objects, the cuing phase ended and a brightly colored distracter image (e.g., *Sesame Street* character, *Elmo*) appeared at the center of the screen. The distracter image remained on the screen until infants accumulated 1 s of looking toward the image. Next, a blank screen with a fixation cross appeared and the object comparison test trials began (Figure 3). The cued and uncued object remained on the screen for 5 s of accumulated looking; fixations made outside of the cued and uncued object interest areas did not count towards looking time. Once 5 s of looking accumulated the objects automatically switched sides for another 5 s of looking (total of 10 s). This length of looking has been previously used in developmental studies measuring preferential looking toward faces and objects (e.g., Scott & Monesson, 2009; Scott, 2011). Cued object location was randomized for the first test trial; placing it either on the same or opposite side relative to the cuing phase.

Data analyses

Primary caregivers completed an in-depth questionnaire, part of which asked parents to list the five individuals their infant spends the most time with on a weekly basis. The proportion of males, females, as well as own- and other-race individuals infants spent time with was calculated and compared with paired-sample t-tests between age groups.

Eye-tracking was used to record duration of total fixations while infants watched videos of adults shift their eyes towards one of two objects (i.e., cuing phase) and during an object comparison task (i.e., test phase). The present study predicted that the effects of perceptual narrowing for faces across sex and race would be displayed in infants' looking behaviors to cued versus uncued objects. Based on this a priori hypothesis separate paired sample t-tests for 5- and 10-month-old infants were used to analyze the average looking duration toward the face, cued, and uncued object based on the sex (collapsed across race), race (collapsed across sex), and sex with race (e.g., own-race female) of the cuing adult face. Additionally, the proportion of first looks made to the cued versus uncued object was compared to chance with single-sample t-tests for each age based on the cuing face conditions. Average looking duration to the cued and uncued object during the first test trial was analyzed with separate paired sample t-tests at each age based on the sex (collapsed across race), race (collapsed across sex), and sex with race of the cuing face.

CHAPTER 3

RESULTS

Questionnaire data

Paired sample t-tests were conducted between 5- and 10-month old age groups for the proportion of weekly interactions with males, females, own- and other-race individuals. Between ages, there were no significant differences in the proportion of weekly experiences infants had with adults across biological sex or race (Table 1 for means and SD).

Gaze-Cuing Phase

Duration of looking

Infants' duration of looking to the face, cued, and uncued object during the gaze-cuing phase was compared.

5-month-old infants

Overall infants displayed significantly greater looking to the face ($M = 509.38$ ms, $SD = 191.48$) compared to both the cued ($M = 263.09$ ms, $SD = 122.75$) and uncued ($M = 269.59$ ms, $SD = 123.55$) object $t(22) = 4.12$, $p < .001$, $t(22) = 4.04$, $p < .001$, respectively. No differences in looking were found for the cued versus uncued object during the gaze-cuing phase. This finding did not systematically differ for sex (collapsed across race) or race (collapsed across sex) face groups (Appendix B). When sex with race were analyzed (e.g., own-race female) 5-month-old infants displayed significantly longer looking to the uncued ($M = 327.28$ms, $SD = 228.35$) versus cued ($M = 159.17$ ms, SD = 158.73) object t(22) = 2.82, p = .01 when other-race Asian female cuing faces were presented.

10-month-old infants

Infants exhibited significantly greater looking to the face (M = 462.33 ms, SD = 168.29) versus the cued (M = 300.95 ms, SD = 119.61) and uncued (M = 274.42 ms, SD = 119.72) object t(18) = 2.67, p = .02, t(18) = 3.08, p = .01, respectively. This finding did not systematically differ across all sex and race face categories (Appendix B). Ten-month-old infants' looking duration to the cued and uncued object did not significantly differ for any cuing face condition.

Location of first object fixation

Further investigation of the gaze-cuing phase examined the location of infants' first face to object fixation. For both 5- and 10-month-old infants the proportion of first fixations made to the cued object did not significantly differ from chance. This finding was consistent across sex (collapsed across race), race (collapsed across sex), and when sex with race was considered (Appendix C).

Object Comparison Test Trial

Duration of looking to the cued and uncued object was analyzed from the first of two object comparison test trials using paired sample t-tests.

5-month-old infants

Infants looked significantly longer to the uncued (M = 2729.43 ms, SD = 435.70) versus cued (M = 2240.86 ms, SD = 404.23) object when the cuing face was female (collapsed across race) t(22) = -2.82, p = .01 (Figure 4), but not male. No differences in looking to the cued versus uncued object were found based on race (collapsed across sex) or for race combined with sex of the face.

10-month-old infants

Infants looked significantly longer to the uncued (M = 2859.66 ms, SD = 573.63) compared to cued (M = 2113.76 ms, SD = 669.26) object t(18) = -2.67, p = .02, when the cuing face was a female from their *own-race,* but not for either of the other-race female groups (Figure 5) or for any of the male groups. No significant differences in looking to the uncued relative to the cued object were found solely based on race (collapsed across sex) or biological sex (collapsed across race) of the cuing face.

CHAPTER 4

DISCUSSION

The current study examined whether the robust effects of perceptual narrowing were displayed within the context of gaze-cued object encoding. Five-and 10-month-old infants' looking duration during gaze-cuing events with adults who varied by sex and race as well as during the first object comparison test trial were analyzed. Our central prediction was in line with previous research on cued object discrimination and the development of perceptual narrowing. Our findings support these predictions such that 5-month-old infants looked significantly longer to the uncued versus cued object when the cuing face was female regardless of race. However, 10-month-olds only displayed longer looking to the uncued versus cued object if the cuing face was both own-race and female. Infants at both ages showed equal looking to the cued and uncued object when the cuing faces were males and at 10 months when cuing faces were other-race female faces. These findings demonstrate that infants differentiate between cued and uncued objects and that with age, social group membership based on sex and race of the cuing face become more influential in this process. Importantly, present findings indicate that similar to the trajectory of face processing biases in the first year of life, using eye-gaze communication cues is also being shaped by experience.

Our finding that infants look longer at the uncued versus cued object is consistent with previous work (Cleveland et al., 2007; Hoehl et al., 2013; Okumura et al., 2013b; Reid & Striano, 2005; Theuring et al., 2007; Wahl et al., 2012). This result suggests that infants better encode objects cued by shifts in gaze orientation and that uncued objects are perceived as more novel at test (Hoehl et al., 2013; Reid & Striano, 2005; Wahl et al., 2012). Previous studies have also found better cued object encoding is influenced by qualities of the gaze cuing face such as being human (Okumura et al., 2013b; Wahl et al., 2012) and personal familiarity (Hoehl et al., 2012). These past findings are consistent with the directed attention model (Hoehl et al., 2009; Reid & Striano, 2007), which proposes five stages that infants complete to follow shifts in eye gaze. In the second stage infants identify a relevant social agent, and it is hypothesized that infants will more efficiently identify a familiar versus unfamiliar social agent (i.e., complete stage two), resulting in better processing of gaze-cued objects (Hoehl et al., 2009; Reid & Striano, 2007). However until now, it had been unclear whether infants would display differences in looking towards cued versus uncued objects based on the social groups cuing faces represented (in the absence of personal familiarity). Present results also support the directed attention model's hypothesis and extend familiarity to include social groups based on sex and race. Thus better encoding of cued objects and subsequent visual attention to uncued objects are demonstrated for faces of a sex and race that infants have had extensive experience with.

The development of face processing biases is hypothesized to be an experience-dependent effect, which is supported by work finding that infants gain the majority of their social experiences with people of the same age, sex, and race as their primary caregiver (Rennels & Davis, 2008; Sugden et al., 2014). Similarly, primary caregivers in our sample reported their infants spent the majority of their time with females of their own-race; this did not change with age (Table 1). Although the amount of time spent with females and own-race adults was not changing between 5 and 10 months of age, infants' encoding of gaze-cued events was tuned by these experiences.

Previous findings suggest that infants display a female face bias by 3 months of age (Hillairet de Boisferon et al., 2014; Quinn et al., 2002) and gradually learn to differentiate among male faces by 7 months (Fagan, 1976; Righi et al., 2014). However recent ERP research suggests that even at 7 months of age infants' neural responses reflects a female face bias (Righi et al., 2014). Combined with the current findings, these data indicate that infants raised primarily by women quickly fine-tune their perceptual processing to female faces and may maintain this bias even as they develop reliable abilities to differentiate male faces. Face biases based on race and species follow a narrowing trajectory of between 3 and 9 months of age (for reviews see Pascalis et al., 2011; Scherf & Scott, 2012; Scott et al., 2007). At 3 months, infants readily differentiate between faces within several race groups, however by 9 months infants display decrease in their sensitivity to differentiating among faces within unfamiliar groups (Kelly et al., 2009; Kelly, Quinn, et al., 2007). Our results are consistent with perceptual narrowing trajectories for both sex and race face groups and extend the effects of these biases beyond the domain of face differentiation. In previous work, infants have been found to display own-race face biases in tasks that involve faces, but not face differentiation (Fassbender et al., 2012; 2014; Vogel et al., 2012). For example, Vogel and colleagues (2012) found that at 9 months, infants displayed race-specific neural processing of emotion faces. Nine-month-old infants had larger perceptual response to own- versus other-race faces and differentially processed emotion sound-face congruency for own-race faces but not other-race faces (Vogel et al., 2012). The present investigation supports this previous work (Fassbender et al., 2012; 2014; Vogel et al., 2012) and suggests that infants' prior experiences influence allocating attention when processing information expressed by faces (e.g., emotion or eye-gaze). This conclusion is consistent with a recent proposal by Pascalis and colleagues (2014). The authors suggest that perceptual narrowing reflects a process in which infants become better prepared to engage in an environment with highly familiar social groups. Within this framework our findings suggest that eye gaze is a type of communication cue affected by perceptual narrowing.

One explanation for the present findings is that looking during the cuing events differed based on the race and sex of the face. For example, Okumura and colleagues (2013b) found infants looked longer to cued targets for human, but not robots when they saw shifts in eye gaze. However, here infants displayed similar looking during cuing events across face conditions. Both 5- and 10-month-old infants exhibited longer looking to the face than either object and did not significantly differ in looking time between the cued and uncued object during the cuing phase. This null result is consistent with previous work by Wahl and colleagues (2012).

Unexpectedly we found that 5-month-old infants looked significantly longer to the uncued versus cued object during the cuing phase for other-race Asian female faces. It is possible that a low-level stimulus difference led infants to look longer to the uncued object for one of the other-race Asian female faces relative to the others. However, it is important to note that this effect during the cuing phase did not seem to influence later looking behavior during the test phase. Longer looking to uncued objects for familiar face groups suggests that cued objects were encoded differently based on sex and race of cuing faces; however this was not reflected in the infants' looking duration during the cuing event. It is possible that looking duration was not sensitive to the mechanism(s) that led to differential looking at test for objects cued by females versus males as well as own- and other-race faces.

Electrophysiological responses can also be used to examine infants' processing of gaze cued objects (Hoehl et al., 2012; Hoehl, Wiese, & Striano, 2008; Reid et al., 2004). For example, Wahl and colleagues (2012) recorded ERPs in response to cued and uncued objects. Their data showed that the ERP component, that indexes contextual processing or ease of stimulus processing, known as Pb (Karrer, Karrer, Bloom, Chaney, & Davis, 1998; Kopp & Lindenberger, 2011; Webb, Long, & Nelson, 2005) had a significantly larger amplitude to the cued compared to the uncued object (Wahl et al., 2012). Wahl and colleagues (2012) interpreted these findings as evidence that the cued object was easier or more efficiently processed relative to the uncued object further supporting the argument that the uncued object appears to infants as being more novel. Future ERP studies that examine eye-gaze cues from faces that vary by sex and race will provide a better understanding of the influence that perceptual narrowing has on infants' processing of cued and uncued targets.

During the cuing phase, 5- and 10-month-old infants' first fixation to the cued versus uncued object did not differ from chance. This finding is consistent with other research demonstrating that such cuing effects are sensitive to both age and trial duration. Gredebäck and colleagues (2008) found that 5-month-old infants' first fixations were at chance for their first fixation location which may indicate that at this age infants need additional time to fully process eye gaze orientation. In contrast, 6- to 12-month-old infants consistently first fixated to the cued object, however this fixation took approximately 3 s to occur (Gredebäck et al., 2008). The timing of this first cued object fixation exceeds the time allowed in the current study and may account for differences in findings with the present study. Although our brief 1 s cuing phase window may appear as a limitation in the current work, it is consistent with several other studies with similar looking duration results during the object comparison test trial (see Hoehl et al., 2013; Reid & Striano, 2005; Wahl et al., 2012). It is possible that the reduced cuing duration in the current study led to less visual exploration during the gaze cuing phase. However, our findings indicate that, 5–month-old infants gained enough information from females, and 10 month-olds from own-race females' gaze cues, to complete the object comparison test trial. The inclusion of an extended cuing phase may highlight the effects that perceptual narrowing has on infants' following eye gaze to encode cued objects.

Further work is needed to examine the possible conditions that will support or facilitate better processing of targets cued by eye gaze from unfamiliar groups of people. Previous results report that when Caucasian infants were familiarized to three individual other-race Asian faces, they demonstrated differentiation for own- and other-race faces, however infants familiarized to only one Asian face did not display other-race discrimination (Sangrigoli & de Schonen, 2004). Another study found that when 12-month-old infants were given a longer familiarization and test duration they displayed other-species (i.e., monkey) face discrimination (Fair et al., 2012). Training has also been used to experimentally increase experience with a particular face group (Anzures et al., 2012; Heron-Delaney et al., 2011; Pascalis et al., 2005; Scott & Monesson, 2009). In these studies, when infants were trained to associate faces from unfamiliar groups with individual names they exhibited discrimination for faces from within these groups at 9 months of age (Anzures et al., 2012; Heron-Delaney et al., 2011; Pascalis et al., 2005; Scott & Monesson, 2009). Future work is needed to examine whether individual-level name training with male and/or other-race faces will improve encoding eye-gaze following and cued targets.

Conclusions

The current study examined whether face processing biases for sex and race would be reflected in infants' looking behaviors towards cued and uncued objects following gaze cuing events. At 5 months the sex of a face, but not the race of a face, was found to bias encoding objects from shifts in eye gaze. By 10 months, infants only distinguished cued from uncued objects from own-race female gaze cuing faces. The present findings support previous proposals that suggest experience-based familiarity with faces shapes social communication learning during infancy (Hoehl et al., 2009; Pascalis et al., 2014; Reid & Striano, 2007). First, in line with the directed attention model (Hoehl et al., 2009; Reid & Striano, 2007) we find that infants better process objects cued by socially familiar faces. Second, our results are consistent with the proposal by Pascalis and colleagues (2014) that suggests perceptual narrowing is a process that prepares infants to successfully learn communication skills used by members of their social in-group. The current results are the first to demonstrate that perceptual narrowing shape infants' encoding of gaze-cued objects. These findings contribute to our understanding of the extent that early social experiences fine-tune infants' use of attention cues to learn about their environment.

Table 1

Infants' Frequent Social Experiences

	5 month	10 month
Female	0.67	0.63
Male	0.33	0.37
Own-Race	0.96	0.99
Other-Race	0.04	0.01

Note. Parents were asked to list up to 5 people their infant most frequently interacted with on a weekly basis. Table 1 presents the average proportion of people infants interacted with on a weekly basis that are female, male, own- or other-races.

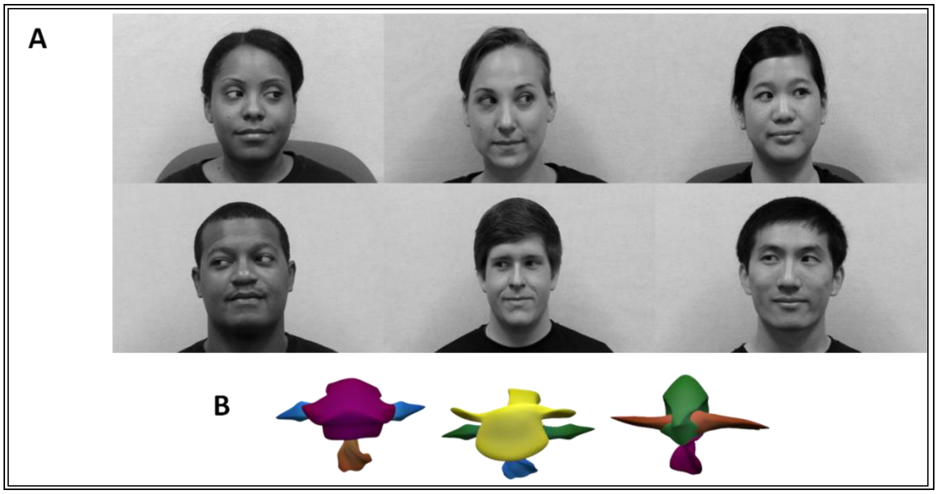

Figure 1. Examples of cuing face videos and object stimuli. Infants saw 2 exemplars of each race-gender face category. Image B includes 3 exemplars of objects used during the cuing as well as test trial phases.

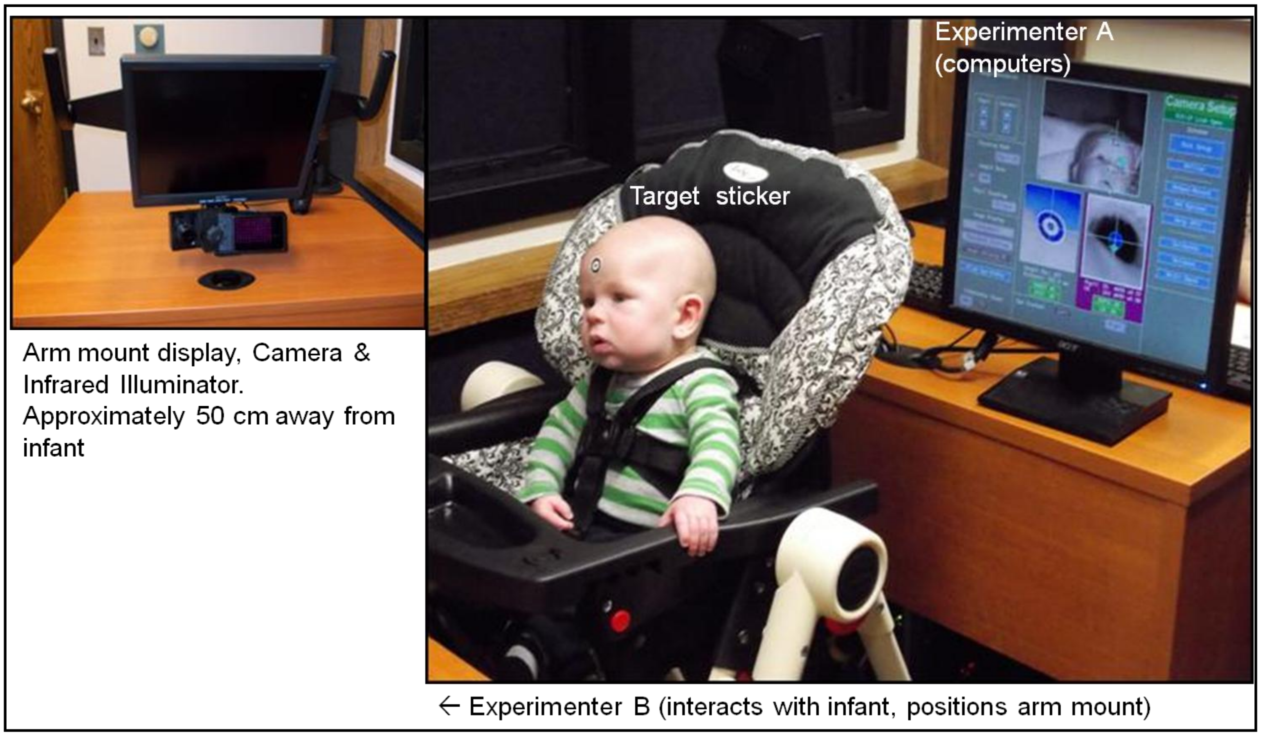

Figure 2. Experimental eye-tracking apparatus set-up. An example of an infant participant with an eye-tracking target sticker placed on his forehead. Infants were seated approximately 50cm away from the display screen, camera, and infrared illuminator. Two experimenters were in the room during testing; experimenter A sat directly behind the infant controlling the eye-tracking computer and experimenter B stood next to the infant to position the arm mount display screen and attend to the infant as needed.

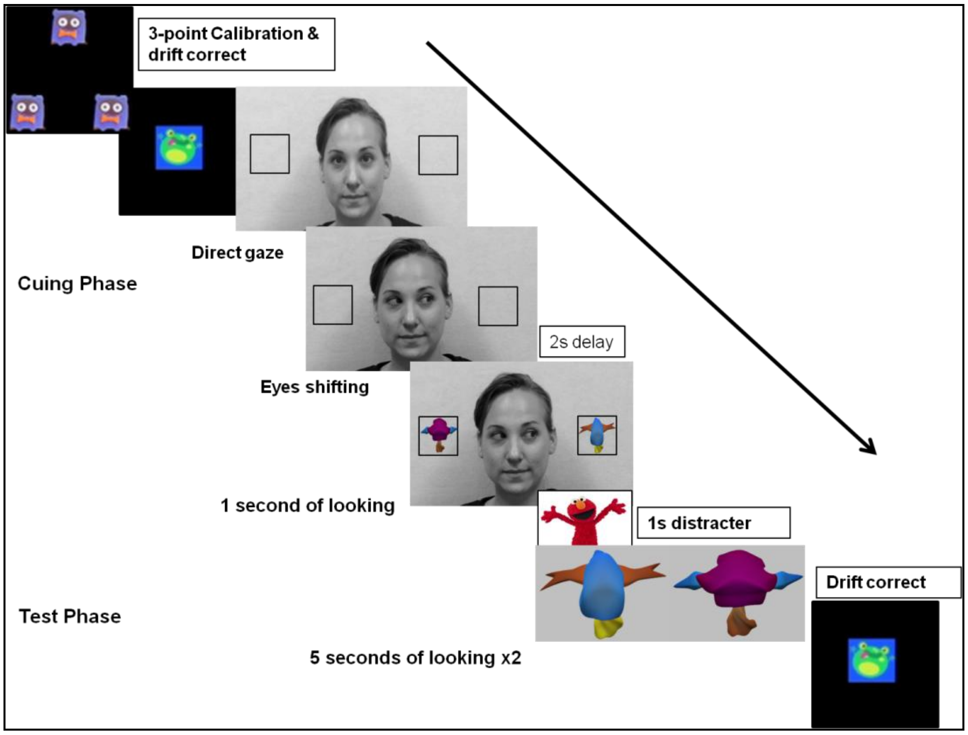

Figure 3. Experimental paradigm trial. Infants first completed a 3-point calibration task prior to beginning the experimental paradigm. Testing procedure included a cuing phase with the adult faces and objects followed by two preferential looking task test trials. Between each trial infants completed an eye-tracking drift correct check. Infants saw a total of 12 trials.

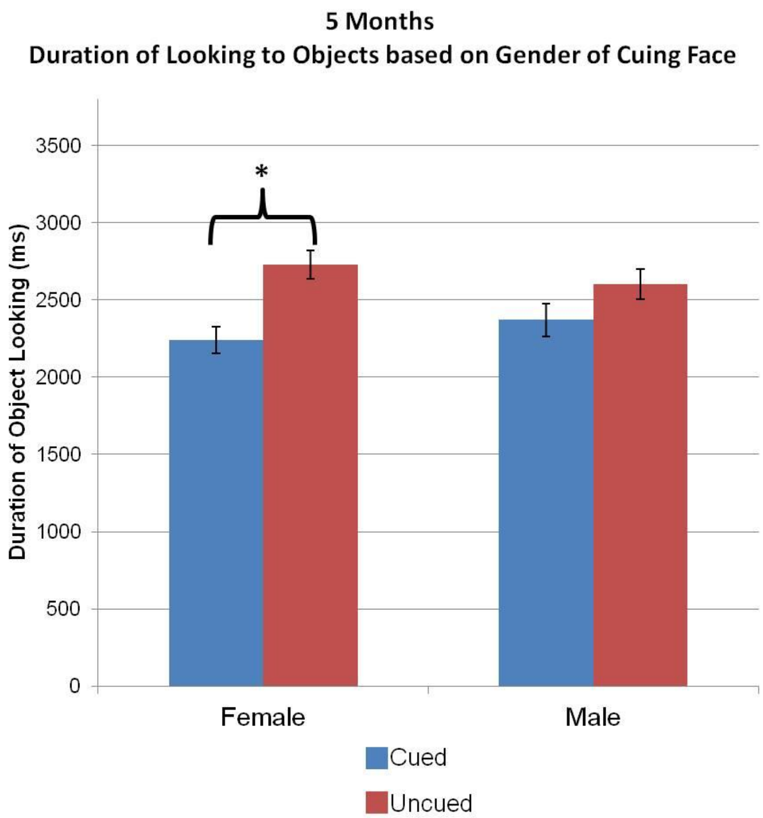

Figure 4. Results from separate paired sample t-tests comparing average looking duration to the cued versus uncued object during the first test trial. Five-month-old infants look significantly longer to the uncued versus cued object when the cuing face was female (across race), but not male face.

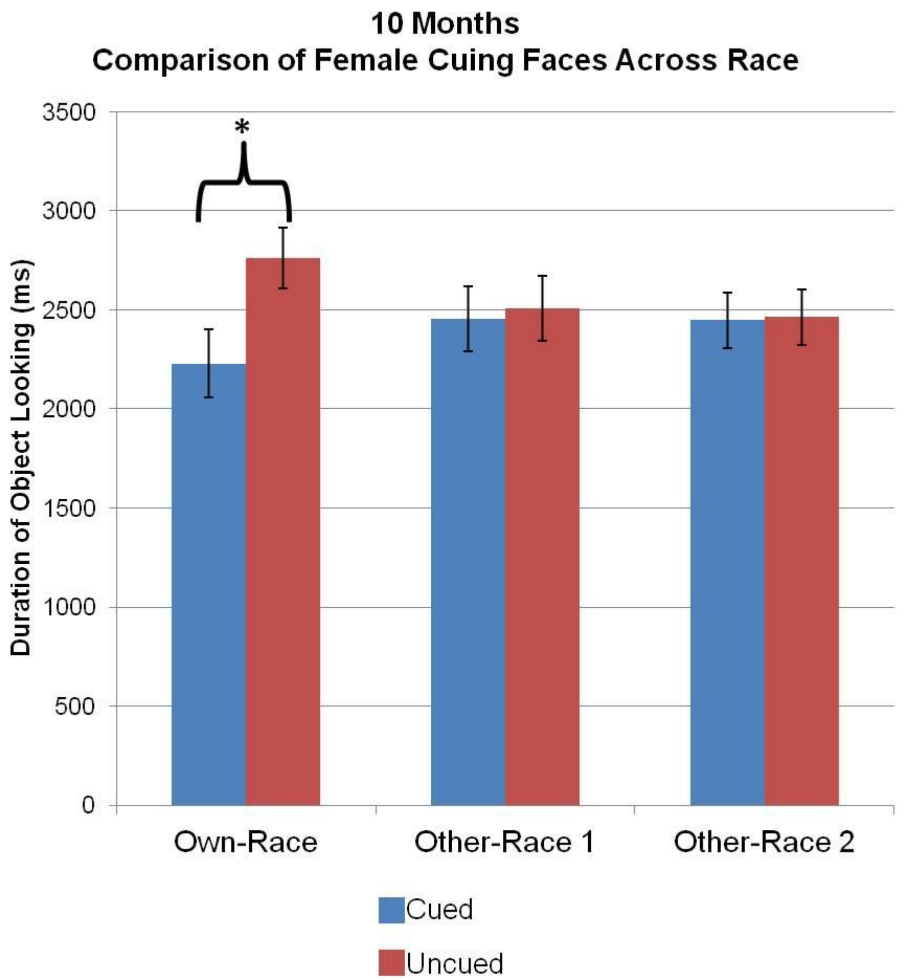

Figure 5. Results from separate paired sample t-tests comparing average looking duration to the cued versus uncued object. Ten-month-old infants looked significantly longer to the uncued compared to the cued object when they previously saw own-race female cuing faces.

APPENDIX A

IN-DEPTH DEMOGRAPHIC QUESTIONNAIRE

What is your infant's gender? Male Female

What is your infant's race (*More than one box may be selected*)?

☐ American Indian or Alaskan Native ☐ Asian
☐ Native Hawaiian or Pacific Islander ☐ White or Caucasian
☐ Black or African American ☐ Does not wish to disclose
☐ Middle Eastern

What is your infant's ethnicity?
☐ Hispanic or Latino ☐ Not Hispanic or Latino

In which country was your infant born? ______________________________

Has s/he ever lived anywhere else? Y \ N

If so, please list:

Location Length of time (approximately)

Who is your infant's primary caregiver and what is their relationship to your infant?

***If the primary caregiver is someone other than parent/guardian 1 or 2 please list their race and gender____**

Parent/Guardian 1: Relationship to your infant _______________ (i.e., Mother, Father)

What is his/her gender? Male Female Does not wish to disclose

Thinking of an average week, what percentage of time does this parent/guardian spend with your infant? _____________ (out of 100%)

Thinking of an average week, what percentage of time does your infant spend with other adults of the same gender as this parent/guardian? _________

Thinking of an average week, what percentage of time does your infant spend with adults of the same race as this parent/guardian? _________

What is parent/guardian 1's race (*More than one box may be selected*)?

☐ American Indian or Alaskan Native ☐ Asian
☐ Native Hawaiian or Pacific Islander ☐ White or Caucasian
☐ Black or African American ☐ Does not wish to disclose
☐ Middle Eastern

What is parent/guardian 1's ethnicity?

☐ Hispanic or Latino ☐ Not Hispanic or Latino

Parent/Guardian 2: Relationship to your infant _______________ (i.e., Mother, Father)

What is his/her gender? Male Female Does not wish to disclose

Thinking of an average week, what percentage of time does parent/guardian 2 spend with your infant? _____________ (out of 100%)

Thinking of an average week, what percentage of time does your infant spend with adults of the same gender as this parent/guardian? _________

Thinking of an average week, what percentage of time does your infant spend with adults of the same race as this parent/guardian? _________

What is parent/guardian 2's race (*More than one box may be selected*)?

☐ American Indian or Alaskan Native
☐ Native Hawaiian or Pacific Islander
☐ Black or African American
☐ Middle Eastern
☐ Asian
☐ White or Caucasian
☐ Does not wish to disclose

What is parent/guardian 2's ethnicity?

☐ Hispanic or Latino ☐ Not Hispanic or Latino

Please indicate the five individuals with whom your infant has the most contact on a weekly basis (list by relationship to infant, (e.g., mother, father, aunt, daycare provider, babysitter, etc.), their gender, race, and an estimate of the relative percentage of time spent with that individual (out of a total 100%):

Does your infant have any relatives (by birth or by marriage) or caretakers who are members of a race or ethnic group other than yours? Y \ N

If so, please list:

Their Race Ethnicity	Relationship to infant (aunt, cousin, etc.)	How often does the infant see them (Approximately)? (Daily, Weekly, Monthly, Yearly, Less than a year)

Has your infant ever lived with people from other racial groups? Y \ N

If so, please list:

Their Race or Ethnicity	Length of cohabitation	Infant's age during cohabitation (approximately)

APPENDIX B

FACE AND OBJECT DURATION OF LOOKING DURING GAZE-CUING PHASE

5-month-old Looking Duration: Sex of Face

Sex	Comparison	*Mean (SD)*	*t*	*p*
Female	Face vs.	501.87 (212.69)	4.78	< .001
	Cued	223.45 (106.56)		
	Face vs.	501.87 (212.69)	2.26	.03
	Uncued	316.96 (193.70)		
	Cued vs.	223.45 (106.56)	-2.02	.06
	Uncued	316.96 (193.70)		
Male	Face vs.	524.14 (211.30)	3.00	.007
	Cued	289.90 (183.13)		
	Face vs.	524.14 (211.30)	4.49	< .001
	Uncued	237.41 (140.49)		
	Cued vs.	289.90 (183.13)	1.04	.31
	Uncued	237.41 (140.49)		

5-month-old Looking Duration: Race of Face

Race	Comparison	*Mean (SD)*	*t*	*p*
Own	Face vs.	519.02 (228.93)	2.99	.007
Caucasian	Cued	276.74 (189.27)		
	Face vs.	519.02 (228.93)	3.41	.002
	Uncued	269.15 (159.59)		
	Cued vs.	276.74 (189.27)	.15	.89
	Uncued	269.15 (159.59)		
Other-race_1	Face vs.	514.40 (210.04)	4.20	< .001
Asian	Cued	237.15 (150.34)		
	Face vs.	514.40 (210.04)	3.06	.006
	Uncued	285.53 (176.69)		
	Cued vs.	237.15 (150.34)	-.95	.34
	Uncued	285.53 (176.69)		
Other-race_2	Face vs.	505.59 (225.27)	3.55	.002
African-American	Cued	256.13 (142.39)		
	Face vs.	505.59 (225.27)	3.11	.005
	Uncued	276.87 (148.34)		
	Cued vs.	256.13 (142.39)	-.51	.62
	Uncued	276.87 (148.34)		

5-month-old Looking Duration: Sex & Race of Face

Sex	Race	Comparison	Mean (SD)	*t*	*p*
Female	Own Caucasian	Face vs. Cued	494.98 (266.44) 223.98 (206.65)	3.26	.004
		Face vs. Uncued	494.98 (266.44) 337.41 (289.28)	1.48	.15
		Cued vs. Uncued	223.98 (206.65) 337.41 (289.28)	-1.35	.19
	Other_1 Asian	Face vs. Cued	534.11 (241.77) 159.17 (158.73)	5.17	< .001
		Face vs. Uncued	534.11 (241.77) 327.28 (228.35)	2.22	.04
		Cued vs. Uncued	159.17 (158.73) 327.28 (228.35)	-2.82	.01
	Other_2 African-American	Face vs. Cued	476.52 (260.70) 287.20 (152.21)	2.53	.02
		Face vs. Uncued	476.52 (260.70) 286.17 (200.97)	2.08	.05
		Cued vs. Uncued	287.20 (152.21) 286.17 (200.97)	.02	.99
Male	Own Caucasian	Face vs. Cued	543.07 (248.98) 329.50 (284.93)	2.06	.05
		Face vs. Uncued	543.07 (248.98) 200.89 (193.08)	4.87	< .001
		Cued vs. Uncued	329.50 (284.93) 200.89 (193.08)	1.48	.15
	Other_1 Asian	Face vs. Cued	494.70 (256.99) 315.13 (241.91)	1.99	.06
		Face vs. Uncued	494.70 (256.99) 243.78 (225.16)	2.84	.01
		Cued vs. Uncued	315.13 (241.91) 243.78 (225.16)	.90	.38
	Other_2 African-American	Face vs. Cued	534.65 (260.76) 225.07 (192.74)	3.53	.002
		Face vs. Uncued	534.65 (260.76) 267.57 (176.57)	3.21	.004
		Cued vs. Uncued	225.07 (192.74) 267.57 (176.57)	-.77	.45

10-month-old Looking Duration: Sex of Face

Sex	Comparison	*Mean (SD)*	*t*	*p*
Female	Face vs.	486.22 (178.95)	3.24	.004
	Cued	284.67 (119.26)		
	Face vs.	486.22 (178.95)	3.10	.006
	Uncued	270.41 (148.99)		
	Cued vs.	284.67 (119.26)	.32	.76
	Uncued	270.41 (148.99)		
Male	Face vs.	438.45 (188.70)	1.76	.10
	Cued	317.23 (148.25)		
	Face vs.	438.45 (188.70)	2.39	.03
	Uncued	278.42 (138.25)		
	Cued vs.	317.23 (148.25)	.74	.47
	Uncued	278.42 (138.25)		

10-month-old Looking Duration: Race of Face

Race	Comparison	*Mean (SD)*	*t*	*p*
Own	Face vs.	497.26 (214.10)	2.54	.02
Caucasian	Cued	287.16 (174.59)		
	Face vs.	497.26 (214.10)	3.49	.003
	Uncued	245.38 (147.62)		
	Cued vs.	287.16 (174.59)	.74	.47
	Uncued	245.38 (147.62)		
Other-race_1	Face vs.	445.83 (184.93)	2.26	.04
Asian	Cued	292.43 (188.82)		
	Face vs.	445.83 (184.93)	1.69	.11
	Uncued	312.30 (206.34)		
	Cued vs.	292.43 (188.82)	-.24	.81
	Uncued	312.30 (206.34)		
Other-race_2	Face vs.	443.91 (191.79)	1.68	.11
African-American	Cued	323.26 (153.72)		
	Face vs.	443.91 (191.79)	2.47	.02
	Uncued	265.57 (154.45)		
	Cued vs.	323.26 (153.72)	1.09	.29
	Uncued	265.57 (154.45)		

10-month-old Looking Duration: Sex & Race of Face

Sex	Race	Comparison	Mean (SD)	*t*	*p*
Female	Own Caucasian	Face vs. Cued	508.82 (185.60) 295.89 (225.24)	2.42	.03
		Face vs. Uncued	508.82 (185.60) 227.32 (183.12)	4.27	< .001
		Cued vs. Uncued	295.89 (225.24) 227.32 (183.12)	.86	.40
	Other_1 Asian	Face vs. Cued	472.24 (278.46) 265.66 (234.99)	2.28	.04
		Face vs. Uncued	472.24 (278.45) 310.37 (312.35)	1.30	.21
		Cued vs. Uncued	265.66 (234.99) 310.37 (312.35)	-.40	.69
	Other_2 African-American	Face vs. Cued	477.61 (245.95) 292.47 (208.03)	1.98	.06
		Face vs. Uncued	477.61 (245.95) 273.55 (216.34)	2.15	.05
		Cued vs. Uncued	292.47 (208.03) 273.55 (216.34)	.24	.81
Male	Own Caucasian	Face vs. Cued	485.71 (281.18) 278.42 (209.03)	2.11	.05
		Face vs. Uncued	485.71 (281.18) 263.45 (209.03)	2.17	.04
		Cued vs. Uncued	278.42 (209.03) 263.45 (209.03)	.19	.85
	Other_1 Asian	Face vs. Cued	419.42 (241.07) 319.21 (264.13)	.96	.35
		Face vs. Uncued	419.42 (241.07) 314.24 (212.25)	1.30	.21
		Cued vs. Uncued	319.21 (264.13) 314.24 (212.25)	.05	.96
	Other_2 African-American	Face vs. Cued	410.21 (208.28) 354.05 (211.87)	.67	.51
		Face vs. Uncued	410.21 (208.28) 257.58 (217.55)	1.82	.09
		Cued vs. Uncued	354.05 (211.87) 257.58 (217.55)	1.16	.26

APPENDIX C

PROPORTION OF FIRST FIXATIONS MADE TO CUED OBJECT DURING GAZE-CUING PHASE

5-month-old Proportion Cued Object First Look: Sex of Face (N = 23)

Sex	Mean (SD)	*t*	*p*
Female	.45 (.22)	-1.16	.26
Male	.48 (.25)	-.34	.74

5-month-old Proportion Cued Object First Look: Race of Face (N =23)

Race	Mean (SD)	*t*	*p*
Own Caucasian	.48 (.25)	-.42	.68
Other-race 1 Asian	.50 (.26)	-.07	.95
Other-race 2 African-American	.43 (.18)	-2.00	.06

5-month-old Proportion Cued Object First Look: Race and Female Face (N = 21)

Race-female	Mean (SD)	*t*	*p*
Own-female Caucasian	.45 (.42)	-.53	.61
Other-race female 1 Asian	.43 (.33)	-1.00	.33
Other-race female 2 African-American	.48 (.29)	-.37	.72

5-month-old Proportion Cued Object First Look: Race and Male Face (N = 20)

Race-male	Mean (SD)	*t*	*p*
Own-male Caucasian	.55 (.39)	.57	.58
Other-race male 1 Asian	.55 (.36)	.62	.54
Other-race male 2 African-American	.43 (.29)	-1.14	.27

10-month-old Proportion Cued Object First Look: Sex of Face (N = 19)

Sex	Mean (SD)	*t*	*p*
Female	.50	.01	.99
Male	.50	.02	.98

10-month-old Proportion Cued Object First Look: Race of Face (N =19)

Race	Mean (SD)	*t*	*p*
Own Caucasian	.53	.53	.61
Other-race 1 Asian	.41	-1.46	.16
Other-race 2 African-American	.55	.97	.35

10-month-old Proportion Cued Object First Look: Race and Female Face (N = 18)

Race-female	Mean (SD)	*t*	*p*
Own-female Caucasian	.58	1.00	.33
Other-race female 1 Asian	.44	-.57	.58
Other-race female 2 African-American	.47	-.33	.75

10-month-old Proportion Cued Object First Look: Race and Male Face (N = 18)

Race-male	Mean (SD)	*t*	*p*
Own-male Caucasian	.50	.00	1.00
Other-race male 1 Asian	.39	-1.29	.22
Other-race male 2 African-American	.64	1.76	.10

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