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The Happy Effect: The Role of Familiarity
in the Development of Face Processing During Infancy

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy
in Psychology

by

Hojin Isaac Kim

2013

ABSTRACT OF THE DISSERTATION

The Happy Effect: The Role of Familiarity
in the Development of Face Processing During Infancy

by

Hojin Isaac Kim

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2013

Professor Scott P. Johnson, Chair

Beginning early in life, infants become familiar with specific kinds of voices and faces through undergoing countless repeated experiences with them. Consequently, infants quickly develop heightened sensitivity for these familiar audiovisual stimuli over the unfamiliar counterparts. In particular, infants are very familiar with happiness as it is ubiquitously present in their social environment. The present study has a two-fold objective. In a series of four studies, it aims to investigate how infants' respond to happiness across modalities and how the perception of happiness influences the way infants perceive familiar and unfamiliar faces, by measuring their eye movements on various types of faces. The first study examines the development of infants' perception of facial, vocal, and intermodal expressions of happiness and sadness in 5- and 8-month-olds. The second study examines 3- and 5-month-olds' differential response to infant-directed (ID) and adult-directed (AD) faces and how speech influences their looking behavior to

faces. The third study further examines how much of infants' preferential response to ID faces can be explained by their overall preference for happy faces. Finally, the fourth study examines if infants' heightened sensitivity to happiness would affect the way they process own- and other-race faces by examining the other-race effect (ORE) in 9-month-old Caucasian infants. Overall, the present series of studies provide comprehensive body of evidence for infants' familiarity with and preference for happiness across different stages of their development within the first year of life. Furthermore, it demonstrated that the use of happiness in faces facilitated infants' discriminatory ability in both own- and other-race faces.

The dissertation of Hojin Isaac Kim is approved.

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2013

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PUBLICATIONS

- Kim, H. I., & Johnson, S. P.** (2013). Do young infants prefer an infant-directed face or a happy face? *International Journal of Behavioral Development*, *37*, 125-130.
- Kim, H. I., & Johnson, S. P.** (2009). Infant Perception. *Encyclopedia of Perception* (Vol 1, pp. 496-501). Thousand Oaks, CA: SAGE Publications.

Introduction

As the great American psychologist William James once suggested, a newborn infant's first impression of the world could be described "as one great blooming, buzzing confusion." This is a sensible observation because infants are born into a world full of interesting things to look at and sounds to listen to while infants' immature perceptual system and the lack of experiences hinder them from easily making sense of the stimuli that constantly bombard their sensory system. In a seemingly chaotic environment, however, newborns quickly become familiar with a few types of auditory and visual stimuli that are frequently and consistently available in their social environment, such as voices and faces.

In fact, newborns can make some sense of the things they hear because infants' experiences with voices begin prenatally and the auditory system is much more developed than the visual system at birth (Aslin, 1987). For example, several studies have shown newborns' ability to recognize a familiar voice (DeCasper & Fifer, 1980; Fifer & Moon, 1989), a familiar story (DeCasper & Spence, 1986), and a familiar language (Moon, Cooper, & Fifer, 1993). Most notably, infants are very familiar with their mother's voice. DeCasper and Fifer (1980) examined 3-day-old newborns' sucking response to their maternal voices and non-maternal voices, and demonstrated that newborns reliably differed in their rate of sucking responses to different voices, suggesting newborns' ability to discriminate between familiar and unfamiliar voices. Moreover, the same newborns produced more sucking behavior in an attempt to continue to listen to their mother's voice, suggesting their preference for maternal voices. Taken together, these findings demonstrate how quickly the effects of prenatal auditory experiences with familiar voices can be observed in infants.

In addition to their familiarity with specific types of voices, infants gradually become very familiar with a language that is frequently spoken to and around them. Compared to their native language, however, infants are far less experienced with non-native languages simply due to the lack of exposure. Thus, this asymmetrical pattern of experiences with languages is known to strongly influence the way infants perceive speech sounds throughout the first year of life. For example, infants in the first few months are able to detect subtle contrasts of phonemes present in both their native language and unfamiliar languages. However, infants as early as 8 months can no longer discriminate phonemic contrasts in unfamiliar languages while still being able to do so in their native language (e.g, Hollich & Houston, 2007; Kuhl et al., 2006; Nazzi, Jusczyk, & Johnson, 2000; Werker, 1989).

Similar to voices, infants encounter faces much more frequently other types of visual stimuli in their surrounding. Human faces are considered to be a special category of visual stimuli to infants because they prefer faces to other visual stimuli shortly after birth, without much prior visual experience. For example, newborns visually track a moving face-like schematic pattern more than a pattern containing the same features in a scrambled fashion just a few minutes after birth (Goren et al., 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991; Maurere & Young, 1983), and look longer at face-like stimuli with features arranged naturally rather than at those with features arranged unnaturally (Turati, Simion, Milani & Umilta, 2002; Valenza, Simion, Cassia, & Umilta, 1996). Taken together, these finding demonstrate that infants' face preference is found very early in life, and suggest that perhaps infants are born with a bias to attend to faces, albeit in a general way.

In the first few months of life, while infants continue to be exposed to countless faces of individuals ranging from their parents, siblings, other family members, friends to strangers, they

gradually become familiarized with specific types of faces much more so than others, such as maternal faces, upright faces, same-race faces, and female faces. It has been suggested that infants by 3 months of age show some signs of perceptual specialization in their processing of faces (de Haan, Psacalis, & Johnson, 2002; Halit, Csibra, Volein, & Johnson, 2004; Humphreys & Johnson, 2007), and infants' asymmetrical experiences with familiar faces seem to specify the way infants process faces overall. For example, by 3 months of age, infants who have a female primary caregiver prefer to look at female faces when they are displayed with male faces, subsequently prefer a novel female face over a familiar female face after shown a set of female faces, but do not show a novelty preference for a new male face over a familiar male face after shown a set of male faces (Quinn et al., 2002). Interestingly, however, infants raised by a male primary caregiver show the opposite pattern of behavior such that they prefer male faces over female faces (Quinn et al., 2002). Similarly, 3-month-old infants show a similar pattern of behavior to their own-race faces such that 3-month-olds, but not newborns, prefer their own-race faces to other-race faces (Kelly et al., 2005).

Infants' heightened sensitivity to their own-race faces continues to develop in the second half of the first year as infants become more familiar with their own-race faces. Such familiarity with own-race faces leads to infants' discriminatory ability in multiple examples of own-race faces, but not in other-race faces. For example, Kelly and colleagues (2007) examined the other-race effect (ORE) in 3-, 6-, and 9-month-old Caucasian infants using Caucasian, Asian, Middle Eastern, and African faces, and found that while 3-month-olds could discriminate faces within both their own- and other-racial groups, infants began to show signs of the ORE at 6 months such that they were no longer able to discriminate Middle Eastern and African faces. Moreover,

by 9 months, infants are only able to discriminate own-race faces and show poor recognition in all other-race faces.

Taken together, there is overwhelming evidence suggesting the importance of familiar stimuli on the way infants' perceptual system becomes specialized throughout the first year of life. Interestingly, however, most recent studies addressing this issue do not take into account the potential effect of another kind of stimuli infants are very familiar with: happiness.

Happiness is ubiquitous in infants' social environment, thus infants quickly become familiar with happiness. Happiness, unlike other types of familiar stimuli such as native language and familiar faces, can be manifested in several forms across multiple modalities. Most notably, voices and faces are frequently used to convey happiness, and more often than not, they are used together simultaneously to effectively communicate happiness to infants. For example, infant-directed (ID) speech is known to arise from the vocal expression of emotions (Trainor et al., 2000), and infants' preference for ID speech is mostly explained by their preference for the vocal expression of happiness (Singh et al., 2002). Similarly, in addition to other important characteristics, the key feature of faces used to communicate with infants is that those faces contain much visual expression of happiness (Stern, 1974).

Because of the ever-present nature of happiness in their social environment, it can be argued that infants are more familiar with happy faces than they are with faces expressing any other emotions. Moreover, such familiarity in turn allows infants to exhibit their heightened sensitivity to happy faces in their behaviors such that infants can discriminate and categorize happy faces before any other facial expressions. For example, infants at 3 months can reliably discriminate happy faces from facial expressions of other emotions (e.g., Barrera & Maurer, 1981; LaBarbera, Izard, Vietze, & Parisi, 1976; Young-Browne, Rosenfeld, & Horowitz, 1978).

In sum, I argue that it is necessary to examine happiness as a familiar emotion during infancy. Similar to infants' familiarity with native language and own-race faces, infants' familiarity with happiness would affect the development of infants' perceptual system in the first year of life. Therefore, in a series of four studies, I investigated (1) how infants respond to happiness across modalities, and (2) how happiness influences the way infants perceive familiar and unfamiliar faces. The first study examined the development of infants' perception of facial, vocal, and intermodal expressions of two distinctive emotions: happiness and sadness. In the second study, I examined infants' differential response to infant-directed (ID) and adult-directed (AD) faces and the potential role of speech in infants' looking behavior. In the third study, I further examined how much of infants' preferential response to ID faces could be explained by their overall preference for happy faces. Finally, in the fourth study, I examined if infants' sensitivity to happiness would influence the way infants process own-race and other-race faces.

Study 1: Intermodal Perception of Happiness and Sadness by 5- and 8-month-old infants

Reading emotional expressions of others, especially during face-to-face interactions, is one of the fundamental social skills for humans. It not only informs us others' current emotional state but also allows us to interact with them in a socially appropriate manner. Despite a seemingly challenging task, most adults can quite accurately perceive emotional expressions of others. Darwin (1872) argued that recognizing emotional expressions could be an adaptive skill, suggesting it to be emerged early in life. Although the development of emotion processing undoubtedly continues beyond infancy, how it develops during the first year of life is the interest of the present study.

Emotional expressions are ubiquitous in infants' social environment. Beginning at birth, infants spend most of their waking hours with their parents who serve as the primary caregivers, and almost all face-to-face interactions occurring between infants and their parents involve emotional exchanges (Malatesta & Haviland, 1982). Darwin (1872), in his observation of mother-infant interactions, argued that emotional expressions are the primary mode of communication between the mother and her infant. It has also been suggested that these exchanges of emotional expressions are attributable to creating and maintaining enjoyable encounters between infants and their parents (Campos, Mumme, Kermoian & Campos, 1994), which ultimately allows infants to form a secure attachment (Cohen, Campbell & Ross, 1991; Malatesta, Culver, Tesman & Shepard, 1989).

In particular, faces are used for most emotional exchanges between young infants and their parents, probably because verbal communication is seldom effective early in life (Papousek & Papousek, 2002). Consequently, most research on infants' emotion perception for the past several decades has primarily focused on infants' ability to discriminate facial expressions of

different emotions in static photographs of faces (for reviews, see Ekman & Oster, 1979; Nelson, 1987; Oster, 1981; Walker-Andrews, 1988, 1997). For example, at 3 months of age, infants begin to discriminate between happy and surprised faces (Young-Browne, Rosenfeld & Horowitz, 1978), and happy from angry faces (Barrera & Maurer, 1981). Four-month-old infants show a greater recognition of happy facial expressions (LaBarbera, Izard, Vietze, & Parisi, 1976), and by 7 months, infants can discriminate faces expressing various emotional expressions, such as happiness, surprise, anger, fear, sadness, and disgust (e.g., Kestenbaum & Nelson, 1990; Ludemann & Nelson, 1988). While these studies are insightful regarding infants' ability to discriminate faces based on emotional expressions, they provide only indirect evidence toward infants' emotion perception because static faces alone seldom communicate emotional information in the real world.

Alternatively, our voices also communicate emotional expressions to infants, and there have been a number of studies investigating infants' ability to discriminate vocal expressions of emotion (e.g., Walker-Andrews and Grolnick, 1983; Walker-Andrews and Lennon, 1991). At birth, infants' auditory system is more developed than the visual system (Aslin, 1987), and several studies examined newborns' response to auditory stimuli in order to demonstrate the effects of prenatal auditory experience (e.g., DeCasper & Fifer, 1980; DeCasper & Sigafos, 1983; DeCasper & Spence, 1986). For example, Mastropieri and Turkewitz (1999) found that newborns showed an increase in eye opening behavior to native speech patterns expressing happiness compared to other emotional expressions. However, when similar vocal expressions of emotion were presented in an unfamiliar language, newborns did not respond differently.

In reality, faces and voices are almost always presented together in most social interactions; infants rarely view a face without hearing any voices and rarely hear a voice

without seeing any faces. Several studies examined infants' responses to multimodal emotional expressions by using the intermodal preference technique (Spelke, 1976). In this paradigm, infants simultaneously view two visual displays of filmed facial expressions presented with a single vocal expression whose emotion matches only one of the two facial expressions. Increased looking to the face that matched the emotional expression of the voice soundtrack is considered as evidence for infants' recognition of invariant emotion communicated across modalities. Using the intermodal preference technique, Walker (1982) tested 5- and 7-month-old infants using happy and sad expressions, and found that infants at both ages showed an intermodal match. However, this particular finding was attributable to infants' sensitivity for temporal synchrony rather than their actual ability to detect common emotion across modalities because the vocal track was always synchronized with one of the two dynamic faces. To control for the temporal synchrony, Walker (1982) conducted another experiment in which temporal synchrony between modalities was disrupted by playing the voice track with a 5-second delay. In this experiment, Walker found that 7-month-old infants were able to look proportionately longer at the face that matched the vocal expression of emotion between happy and neutral expressions. Five-month-olds, on the other hand, failed to detect common emotion across modalities when they could not use the temporal synchrony as a cue for matching. Similarly, Soken and Pick (1992) demonstrated that by the age of 7 months, infants could perceive happy and angry expressions across modalities in the absence of the temporal synchrony between face and voice. Taken together, these results suggest that only the older infants who had more experiences of emotional expressions could make use of invariant information to match emotional expressions.

Among many possible comparisons between emotions, I was particularly intrigued by an interesting pattern of results involving two distinct emotions: *happiness* and *sadness*. For example, Soken and Pick (1999) found that while 7-month-old infants were able to intermodally detect expressions of emotion across a variety of positive and negative emotions, such as happy/interest, happy/angry, sad/angry, and interested/angry, they failed to show the same pattern of results in happy/sad and interested/sad conditions. In another study, although Walker (1982) argued that infants by 7 months could do a matching across modalities based on emotional expressions, only one distinct emotion, happiness, was used along with neutral expression rather than using another distinct expression of emotion.

Therefore, the present study was designed to further examine infants' ability to detect across modalities two dissimilar expressions of emotions: happy and sad. I tested 5- and 8-month-old infants using the intermodal preference technique (Spelke, 1976).

Experiment 1

As previously stated, matching the face and voice according to their emotional expressions is a challenging task to infants, especially without any cues of temporal synchrony between modalities. Given that 7-month-olds failed to exhibit signs of intermodal matching in these particular emotion pairing (Soken & Pick, 1999), I predicted that much exposure to both expressions would be required for 8-month-old infants to show any signs of intermodal emotion matching. Moreover, I hypothesized a spontaneous preference for the happy face over the sad face, regardless of the types of voices heard.

Method

Participants. Thirty-two 8-month-old infants (16 boys, 16 girls, $M = 8.11$ months) participated in Experiment 1. Eleven additional infants were tested but were excluded from the

analysis because of fussiness (8) and experimenter/equipment error (3). Infants were recruited by letter and telephone from a list of birth records provided by the Los Angeles County. All infants were full term and had no known developmental difficulties. Parents were provided with a small gift for participation.

Materials. To obtain both facial and vocal expressions of emotion, a female model's face was recorded while she expressed the target emotions (happy and sad) using a Canon camcorder. Throughout the recording session, the model was instructed to maintain a still body and head posture and to direct her gaze at the camcorder, and she was filmed from the shoulders up against a grey background under normal lighting. The female model was a mother of young infants. To induce the target emotion, she was asked to think about situations that would make her happy or sad. This method of inducing affect has been employed in previous studies (e.g., Haviland & Lelwica, 1987). Prior to the recording session, the model was asked to practice her facial expressions using a mirror. She was also instructed to speak continuously to a photo of a baby, as if she would speak to her child, thus, both happy and sad expressions were performed in infant-directed manner. She used a high-pitched and rhythmical speech when expressing happiness, and to avoid both long pauses and a very low pitched voice for the sad expression. She was also instructed not to use names of her child or to make any nonverbal vocalizations.

To finalize the stimuli to be used in the experiment, the recordings were segmented into multiple 20 second clips of video then were put together side by side using Adobe Premiere (see Figure 1). A single vocal soundtrack (happy or sad) was added to each side-by-side face stimuli. Temporal synchrony between faces and voices was eliminated by using independent soundtracks that were never synchronous with either face. There were a total of 16 trials, organized into 2 blocks of 8 trials. Each block contained 2 happy vocal soundtracks and 2 sad vocal soundtracks.

Each soundtrack was presented twice within each block, yielding 4 trials with happy voices and 4 trials of sad voices. Stimuli were presented in one of 8 unique counterbalanced orders with the stipulation that the vocal expression of emotion alternated between happy and sad for every four trials. Furthermore, the left-right presentation of the faces was systematically counterbalanced throughout the study. Each visual stimulus measured 15.2 x 15.9 cm (14.4 x 15.1° visual angle) and was separated by a gap of 0.5 cm (0.5°). Each face measured approximately 10.2 x 7.6 cm (9.7 x 7.3°). See Figure 1 for an example.

Procedures. Infants were tested individually, while being seated on their parents' lap approximately 60 cm from a 17-inch monitor surrounded by black curtains. Eye movements were recorded with a Tobii ET-1750 eye tracker at 60 Hz with a spatial accuracy of approximately .5-1°. The soundtrack came from speakers centrally located behind the monitor. The lights in the experimental room were dimmed and the only source of illumination came from the monitor.

To calibrate each infant's point of gaze, a dynamic target-patterned ball undergoing repeated contraction and expansion around a central point was presented briefly at five locations on the screen (the four corners plus the center) as the infant watched. The Tobii eye tracker provides information about calibration quality for each point; if there were no data for one or more points or if calibration quality was poor, calibration at those points was repeated. Calibration was followed immediately by presentation of faces as described previously. Prior to each trial a small attention-getting stimulus was shown to re-center the point of gaze.

Results and Discussion

The data consisted of 8-month-olds' mean proportion of dwell time on faces per trial. I report here only the eye movements within the faces, recorded by superimposing areas of interest

(AOIs) on the faces using Clearview software (see Figure 1). AOIs were generously sized to accommodate head movement of the model as she spoke.

Of 32 infants, 30 infants completed all 16 trials and 2 infants completed 15 out of 16 trials. On average, infants attended to faces for 53.8% of the time ($SD = 12.0\%$, range = 37.6% - 81.7%) throughout the experiment. Preliminary analyses with the left-right presentation, the order of presentation, and sex of the infants revealed no significance, $F_s < .81$, ns , therefore data were collapsed across these variables in subsequent analyses.

Figure 2 displays 8-month-olds' mean proportion of dwell time on happy and sad faces under different sound conditions. First, a dependent samples t -test using the proportion of dwell time on the faces collapsed across sound conditions yielded a reliable overall preference for the happy face ($M = .53$, $SD = .07$) over the sad face ($M = .47$, $SD = .07$), $t(31) = 4.419$, $p = .04$. Subsequently, a 2 (Block: First 8 trials, Last 8 trials) x 2 (Sound: Happy, Sad) within-subjects analysis of variance (ANOVA) using the proportion of dwell time on the happy face revealed no significant main effect of Block, $F(1, 31) = .002$, $p = .97$, indicating no difference in the proportion of dwell time on the happy face between the first 8 trials ($M = .53$, $SD = .10$) and the last 8 trials ($M = .53$, $SD = .07$). Also, there was no main effect of Sound, $F(1,31) = .546$, $p = .47$, suggesting no difference in looking at the happy face between under happy sound condition ($M = .53$, $SD = .08$) and under sad sound condition ($M = .52$, $SD = .07$). More importantly, there was a significant interaction between Block and Sound, $F(1,31) = 6.652$, $p = .015$, partial $\eta^2 = .18$, suggesting a change in infants' pattern of looking behavior under different sound conditions between the first 8 trials and the last 8 trials. Particularly, a post hoc analysis regarding the Block x Sound interaction revealed that in the first 8 trials, infants did not differ in the proportion of dwell time on the happy face between under happy ($M = .51$, $SD = .11$) and

under sad ($M = .54, SD = .11$) sound conditions, $F(1,31) = 2.106, p = .157$. However, in the last 8 trials, infants significantly looked more at the happy face under happy sound condition ($M = .55, SD = .09$) than under sad sound condition ($M = .50, SD = .10$), $F(1,31) = 4.913, p = .034$, partial $\eta^2 = .14$, indicating an intermodal matching based on emotions only in the last 8 trials.

As predicted, 8-month-old infants showed an overall preference for dynamic happy facial expressions over dynamic sad facial expressions. However, a closer examination of the data revealed that the overall happy face preference was the result of infants' improved intermodal emotion matching response observed exclusively in the second half of the experiment. In other words, infants in the first half of the experiment did not look longer at the happy face than at the sad face, regardless of which sound was presented. However, in the second half of the experiment, 8-month-old infants quickly learned to modulate their looking behavior on faces according to the matching vocal expressions; infants looked reliably longer at the happy face when happy sound was presented while eliminating the happy face preference by increasing their looks on the sad face when sad sound was presented.

Experiment 2

As demonstrated in Experiment 1, infants at 8 months begin to match happy and sad expressions communicated in faces and voices. In this experiment, 5-month-old infants were examined using the same method as Experiment 1, in an attempt to further our understanding regarding the developmental trajectory of an intermodal emotion matching behavior. In particular, I predicted that while they would not be able to match emotions multimodally yet, 5-month-old infants would be able to discriminate facial expressions of happy and sad emotions, which is an ability that needs to be learned and mastered prior to showing any signs of intermodal emotion matching.

Method

Participants. Thirty-two 5-month-old infants (16 boys, 16 girls, $M = 5.13$ months) participated in Experiment 2. Fifteen additional infants were observed but excluded due to fussiness (11) and experimenter/equipment error (4). Infants were recruited by letter and telephone from a commercial list of new parents in New York City. All infants were full term and had no known developmental difficulties. Parents were provided with a small gift for participation.

Materials and Procedure. Materials and procedures were identical to those used in Experiment 1.

Results and Discussion

As in Experiment 1, the data consisted of 5-month-olds' mean proportion of dwell time on faces per trial. Of 32 infants, 28 infants completed all 16 trials and 4 infants completed 15 out of 16 trials. Infants on average produced dwell time on the faces for 42.02% throughout the experiment ($SD = 13.15\%$, range = 15.9% - 71.6%). Preliminary analyses with the left-right presentation, the order of presentation, and gender of the infants revealed no significance, $F_s < .52$, ns , therefore data were collapsed across these variables in subsequent analyses.

Figure 3 displays 5-month-olds' mean proportion of dwell time on happy and sad faces under different sound conditions. First, a dependent samples t -test using the proportion of dwell time on the faces yielded a reliable preference for the happy face ($M = .54$, $SD = .08$) over the sad face ($M = .46$, $SD = .08$), $t(31) = 6.573$, $p = .015$. Subsequently, a 2 (Block: First 8 trials, Last 8 trials) x 2 (Sound: Happy, Sad) within-subjects ANOVA using the proportion of dwell time on the happy face revealed no significant main effect of Block, $F(1, 31) = .000$, $p = .999$, indicating no difference in the proportion of dwell time on the happy face between the first 8

trials ($M = .54$, $SD = .11$) and the last 8 trials ($M = .54$, $SD = .11$). Also, there was no main effect of Sound, $F(1,31) = .393$, $p = .535$, suggesting no difference in looking at the happy face between under happy condition ($M = .53$, $SD = .11$) and under sad sound condition ($M = .55$, $SD = .11$). Moreover, there was no significant interaction between Block and Sound, $F(1,31) = .024$, $p = .878$, indicating no signs of intermodal emotion matching in 5-month-old infants.

As predicted, a reliable preference for the happy face suggests that 5-month-old infants were able to discriminate dynamic expressions of happy and sad faces. Moreover, as also predicted, infants' pattern of looking behaviors did not change over the course of the experiment, which suggests the lack of intermodal emotion matching ability in younger infants.

General Discussion

In the present study, I investigated if 5- and 8-month-old infants can detect expressions of happy and sad emotions both unimodally and intermodally. As hypothesized, both 5- and 8-month-old infants overall reliably looked longer at happy faces while viewing side-by-side displays of happy and sad facial expressions, suggesting infants' ability to visually discriminate between dynamic expressions of happiness and sadness. Moreover, 8-month-olds, but not 5-month-olds, successfully modified their looking behavior on faces according to the matching vocal expressions, but a closer examination of the findings indicated that 8-month-olds were only able to exhibit the intermodal emotion matching behavior after they failed to do so for the first half of the experiment.

In general, these results confirm the previous findings (e.g., Kreutzer & Charlesworth, 1973; Soken & Pick, 1999; Walker, 1982) demonstrating an early sensitivity to dynamic facial expressions of emotion; infants as early as 5 months of age seem able to discriminate happy and sad faces that are more likely to occur in their social environment. The persisting pattern of

infants' visual preference for facial expression of happiness found in both age groups in both sound conditions suggests that infants were primarily captivated by happy faces. Indeed, evidence suggests that among many emotions infants may encounter, infants are thought to have seen and heard the positive expressions, such as happiness, much more so than the negative expressions, such as anger and sad (e.g., Malatesta, Grigoryev, Lamb, Albin, & Culver, 1986; Malatesta & Haviland, 1982), which partly explains infants' affinity for happy faces. For example, happy faces are one of the first emotional expressions to be discriminated (e.g., Barrera & Maurer, 1981; Young-Browne et al., 1978), and to be categorized (Kuckuck et al., 1986) by infants as young as 3 months of age.

Interestingly, although several studies suggested that infants as young as 3 months can distinguish between facial expressions of emotion (e.g., Barrera & Maurer, 1981; Young-Browne et al., 1977), they only showed that 3-month-old infants can discriminate among static photographs of faces which are unlikely to occur in the real world. Unlike dynamic facial expressions of emotion, infants can discriminate static faces without attending to any emotional information because they can reliably use the differences in perceptual features of faces to tell them apart. Moreover, several previous studies show inconsistent patterns of results both within and between studies especially in infants younger than 6 months. For instance, Caron, Caron, and Myers (1982) tested 18-, 24-, and 30-week-old infants' ability to discriminate happy and surprise facial expressions by using an infant-controlled habituation procedure. They found that 30-week-olds were able to discriminate between surprise and happy faces while 18-week-olds could not. However, 24-week-olds successfully differentiated a surprise expression from a happy one only when they were first habituated to the happy expression; when habituated to the surprise expression, 24-week-olds did not show novelty preference for the happy face. In

another study, Caron, Caron, and MacLean (1988) tested 4- and 5-month-old infants' ability to discriminate videotaped happy and sad expressions using an infant-controlled habituation procedure, and found that infants successfully discriminated sad from happy expressions, but only when they were first habituated to the sad expressions. Similarly, Schwartz, Izard, and Ansul (1985) also showed that by 5 months of age, infants can discriminate between interest, sad, fearful, and angry facial expressions, but only if they are first habituated to angry faces and then tested with fearful, sad, or interest faces. Thus, by using dynamic faces instead of static faces, and by using the preferential looking paradigm rather than a habituation paradigm, the present study demonstrates that infants as young as 5 months of age show difference responses to ecologically valid facial expressions of emotion without observing an order effect.

Moreover, an interesting result was found regarding infants' ability to detect the expressions of emotions across multiple modalities. In the present study, only 8-month-old infants showed a differential looking behavior between two vocal expressions: happy and sad. Interestingly, however, it is important to note that 8-month-olds' intermodal emotion matching ability was observed only in the second half of the experiment. In other words, during the first 2.5 minutes of exposure to multiple incidences of happy and sad expressions, 8-month-old infants could not appropriately modify their looking behaviors according to vocal expressions of emotions, which suggests the degree of difficulty involved in learning to detect expressions of emotions across modalities.

In particular, the elimination of the temporal synchrony between the filmed faces and vocal recordings may be attributable to the difficulty 8-month-old infants faced when learning to match emotions intermodally. As mentioned earlier, 7-month-old infants are thought to be able to match happy and sad expressions across modalities only if the temporal synchrony is

maintained in the stimuli (Walker 1982). Although the use of asynchronous audiovisual stimuli was necessary to examine infants' ability to detect common emotion across modalities, by doing so, it may have increased the difficulty of the task because infants almost always experience faces and voices synchronously. It has been demonstrated that infants as young as 2 months of age attend significantly less to the asynchronous presentation of face and voice than the synchronous pair (Dodd, 1979).

In conclusion, the present study depicts a developmental trajectory between the ages of 5 and 8 months. Whereas both 5- and 8-month-olds showed a preference for happy faces over sad faces, only 8-month-olds showed signs of emotion matching across modalities. In both ages, infants' overwhelming facial and vocal experience with happiness (e.g., Malatesta et al., 1986; Malatesta & Haviland, 1982) in their social interactions seem to contribute to their preference for happy expressions. Conversely, infants' lack of experience with sad expressions of emotion, combined with the absence of the temporal synchrony between face and voice seem to negatively influence infants' ability to do an emotion matching across modalities, which suggests that a reliable matching of face and voice solely based on emotion, while a necessary social skill, probably will not emerge until later, probably beginning at 8 months.

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Figure 1. Top row: An example of happy facial expressions (left) and sad facial expressions (right). Bottom row: Areas of interest within which infants' eye movements were recorded.

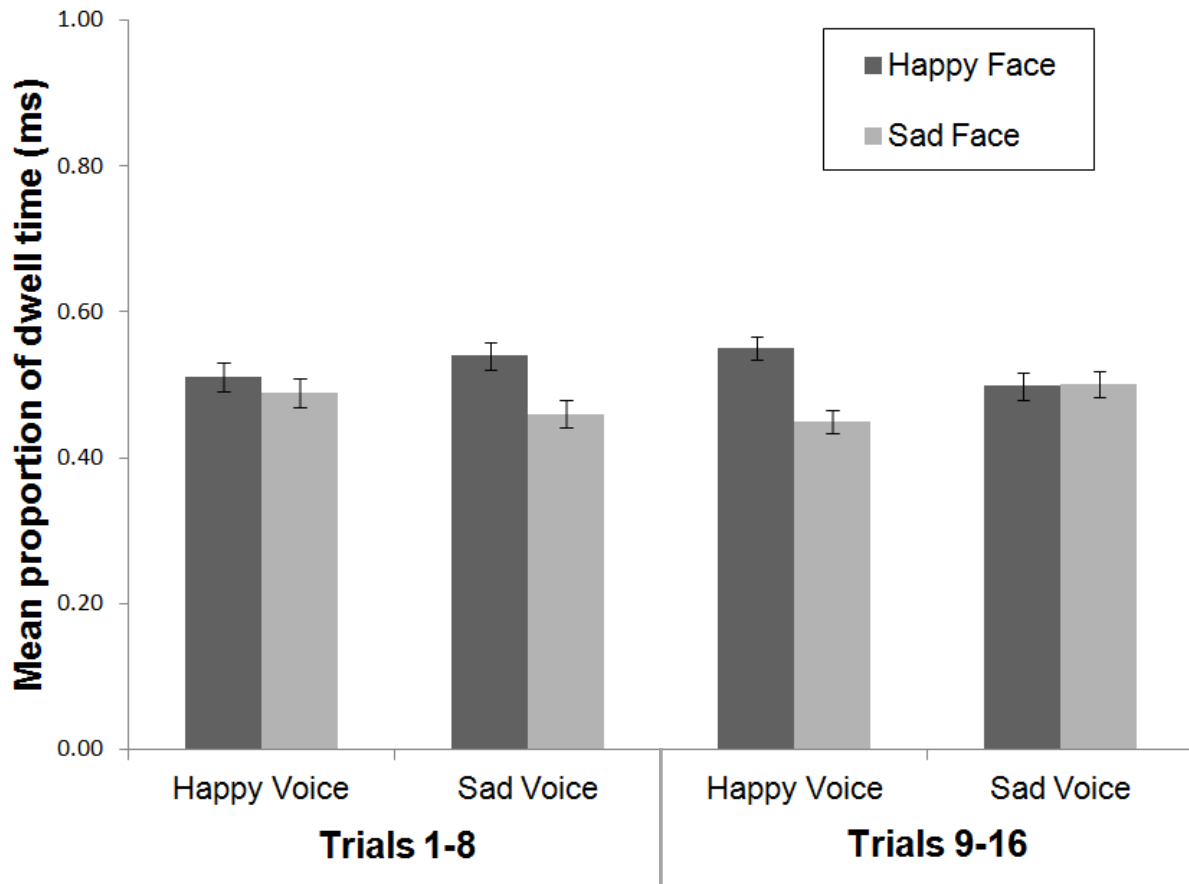


Figure 2. Data from 8-month-olds displaying the mean dwell time on each type of face stimulus (happy and sad) under the two sound conditions (happy and sad) between the first 8 and the last 8 trials. Error bars = *SEM*.

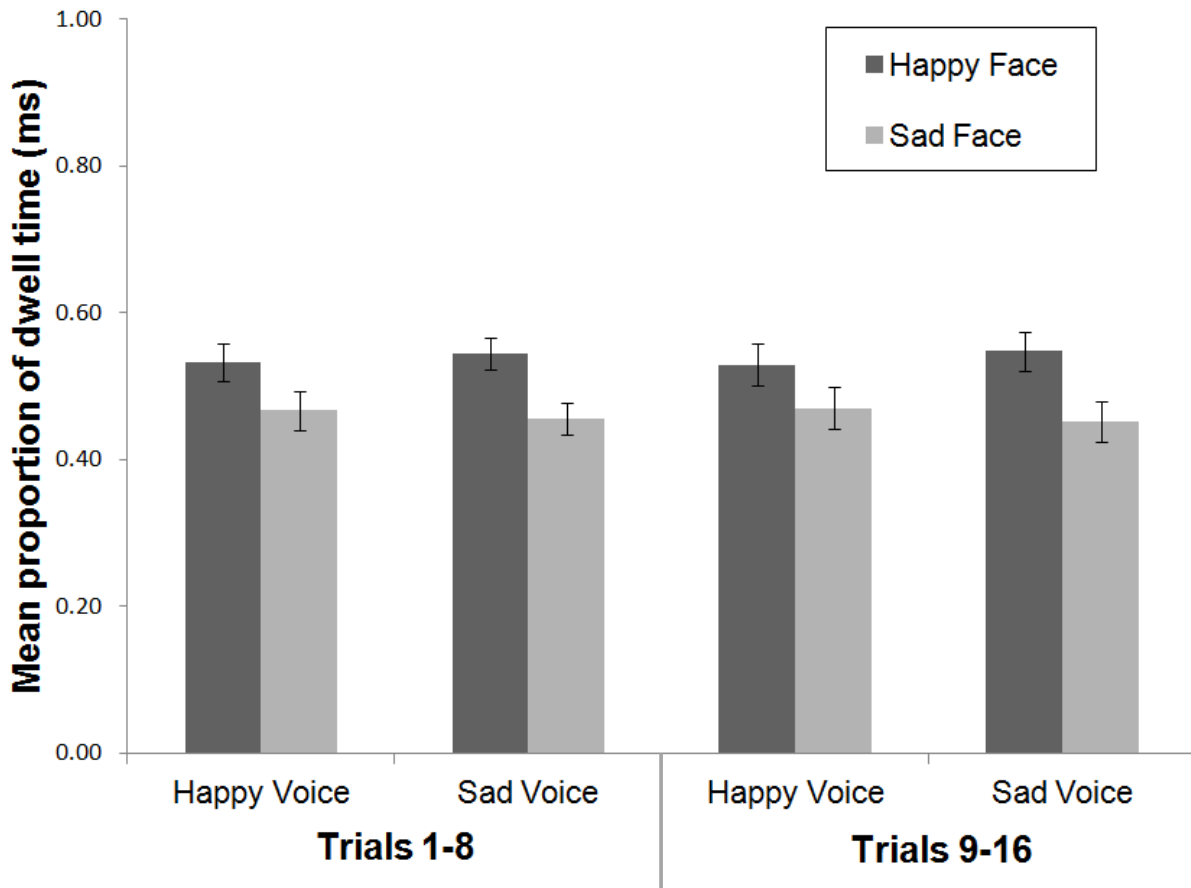


Figure 3. Data from 5-month-olds displaying the mean dwell time on each type of face stimulus (happy and sad) under the two sound conditions (happy and sad) between the first 8 and the last 8 trials. Error bars = *SEM*.

Study 2: Detecting “Infant-directedness” in Face and Voice

The social environment of young infants is markedly different than that of adults. Adults often modify their communicative behaviors when interacting with infants, employing a speech register characterized by elevated fundamental frequency, wider intonation contours, more precise articulation, increased use of repetition, decreased complexity, elongated vowels, reduced speech rate, shorter phrases, and longer pauses (Fernald & Kuhl, 1987; Fernald & Simon, 1984; Kitamura & Burnham, 2003). Infants demonstrate robust preferences for infant-directed (ID) speech over adult-directed (AD) speech (Cooper & Aslin, 1990; Fernald 1985). ID speech has a special propensity to attract and hold infants’ attention (Fernald & Simon, 1984), conveys affective intentions (Fernald, 1992), and facilitates language processing (e.g., Liu, Kuhl, & Tsao, 2003; Thiessen, Hill, & Saffran, 2005; Werker, Pons, Dietrich, Kajikawa, Fais, & Amano, 2007).

Speech, including ID speech, is closely related to facial expressions. The muscles used to produce facial expressions influence the articulation of speech sounds (Massaro, 1998), and infants attend to certain visual cues, especially the mouthing shapes, in faces that produce speech. Kuhl and Meltzoff (1984) used a preferential looking paradigm to investigate 4-month-old infants’ sensitivity to visual cues for the vowels /i/ and /a/. For both vowels, infants looked longer at the face that matched the vowel. Young infants imitate mouth movements when presented with compatible audiovisual representations of vowels (Legerstee, 1990), and are susceptible to the McGurk effect (Burham & Dodd, 2004; Rosenblum, Schmuckler, & Johnson, 1997), an auditory-visual illusion that illustrates how perceivers merge information for speech sounds across the senses (McGurk & MacDonald, 1976). Together these studies provide evidence that infants detect the congruency between facial movement and speech sounds.

Because face and voice present synchronous information, and because infants are

sensitive to some of this information, it raises the question whether facial expressions, like speech, might be appropriately characterized as infant-directed when adults talk to infants. Stern (1974) reported that when speaking to their own infants, mothers' facial expressions were often more exaggerated, slower in tempo, and longer in duration than AD facial expressions. More recently, Chong, Werker, Russell, and Carroll (2003) examined mothers' faces during mother-infant interactions and reported three distinct types of facial expressions: soothing and comfort, amazement and pride, and exaggerated smiles.

In the present study, I asked if infant preference for ID speech could extend to ID faces. Moreover, I asked if infants could match faces and speech according to the register (i.e., ID and AD speech). Young infants prefer ID over AD communication when exposed to talking faces (Werker, Pegg, & McLeod, 1994) and action displays (Brand & Shallcross, 2008), but to my knowledge no previous study has (a) isolated faces and voices, (b) investigated preference for ID faces alone, and then (c) added in the voices to examine modulation of these preferences. I recorded infants' eye movements as they viewed AD and ID faces side-by-side, in silence or accompanied by asynchronous AD or ID speech. I hypothesized that there would be a baseline preference for ID face over AD face (i.e., in silence), and that infant attention toward the faces would be modulated according to the speech they heard during in-sound trials: overcoming the baseline preference in favor of AD face when accompanied by AD speech, and even greater attention to ID face when accompanied by ID speech relative to baseline, the latter effects due to the tendency of infants to look longer at a visual-auditory match relative to a mismatch (cf. Bahrick, 1998). Thus, the present study examines infants' detection of "infant-directedness" in face and voice when they are presented asynchronously.

In a longitudinal study of 30 infants, Lamb, Morrison, and Malkin (1987) demonstrated

that infants' face-to-face play with mothers becomes increasingly frequent and reaches a peak when between 3 and 5 months of age. I reasoned, therefore, that 5-month-old infants may show a multimodal match based on register due to sufficient exposure to infant-directed speech and faces, whereas 3-month-olds, who have more limited experience engaging in face-to-face interaction with adults, would not show the match.

Method

Participants

Forty-two full-term 5-month-olds (21 girls, 21 boys, $M = 5.17$ months, range = 4.2-5.9 months) and 33 full-term 3-month-olds (16 girls, 17 boys, M age = 3.11 months, age range = 2.5-3.6 months) participated in the study. Twenty-six infants were observed but excluded from the analysis due to fussiness (nine 5-month-olds, seven 3-month-olds) or equipment failure/experimenter error (10). Infants were recruited from birth records provided by the county. Parents were first sent a letter of invitation to participate in the experiment; interested parents returned a postcard and were later contacted by telephone. Parents were provided with a small gift for their infants but were not paid for participation.

Materials.

Infants viewed a pair of videotaped events accompanied by a vocal soundtrack. Each event showed a woman's face as she engaged in a live face-to-face interaction with a member of her own family—either her husband or her 18-month-old infant. One woman served as the model for all stimuli. The recording sessions yielded segments of video and audio records that were either adult- or infant-directed.

The model and family members viewed a video monitor showing the person with whom they were conversing during the live interaction (cf. Murray & Trevarthen, 1985). I asked the

model to talk about identical topics (e.g., birthday parties, family vacation) to both listeners for approximately the same duration. Recording sessions of model and family members lasted between 5 and 10 minutes. The model's facial expressions and speech were recorded with a Sony digital camcorder subsequently connected to a Macintosh computer to save the recordings onto the hard drive.

Recordings were segmented into multiple 20-second clips with iMovie software and separated into video and audio files using Adobe Premiere. Sixteen undergraduates (half female and half male) rated the face and speech clips as infant- or adult-directed using a modified Likert scale, a value of 10 denoting a face or speech sample as "definitely produced when she was interacting with an infant" and a value of 1 as "definitely produced when she was interacting with an adult." The six ID face clips and six AD face clips with the highest (most extreme ID) and lowest (most extreme AD) ratings, respectively, were selected to make six side-by-side face stimuli with Adobe Premiere. Overall both the ID speech and the ID face clips were judged to have been more likely produced when the model interacted with an infant, confirming the infant-directedness of the stimuli (see Figure 1). Left-right presentation of the ID face was counterbalanced across presentations within each of the sound conditions. Two ID and two AD speech clips were also chosen based on the adults' ratings. One speech clip was added to each side-by-side face stimulus for a total of eight (four face pairs with ID speech, two with the ID face on the left and two with the ID face on the right, and the same arrangement for the four face pairs with AD speech), and four silent side-by-side face stimuli were created (two with the ID face on the left and two with the ID face on the right). The soundtrack was asynchronous with both faces during in-sound trials. Stimuli were presented in one of four pseudorandom orders with the stipulation that no more than two of any sound condition (ID speech, AD speech, no

speech) could be presented in succession. Each visual stimulus measured 15.2 x 15.9 cm (14.4 x 15.1° visual angle) and was separated by a gap of 2.5 cm (2.4°). Each face measured approximately 10.2 x 7.6 cm (9.7 x 7.3°). See Figure 2 for an example.

The dependent variable in this experiment was the mean dwell time on two side-by-side dynamic face stimuli. On each trial, one of three speech types (ID, AD, and no speech) was presented with two (ID and AD) faces. Each infant was exposed to all three speech types and two faces, presented twice for a total of 12 stimuli, each 20 s in duration.

Procedures

Infants were tested individually, seated on a parent's lap 60 cm from a 17-inch monitor surrounded by black curtains. Eye movements were recorded with a Tobii ET-1750 eye tracker at 60 Hz with a spatial accuracy of approximately 1° (cf. Morgante, Zolfaghari, & Johnson, 2012). The soundtrack came from speakers located behind the monitor. The lights in the experimental room were dimmed and the only source of illumination came from the monitor.

To calibrate each infant's point of gaze, a dynamic target-patterned ball undergoing repeated contraction and expansion around a central point was presented briefly at five locations on the screen (the four corners plus the center) as the infant watched. The Tobii eye tracker provides information about calibration quality for each point; if there were no data for one or more points or if calibration quality was poor, calibration at those points was repeated. Calibration was followed immediately by presentation of faces as described previously. Prior to each trial a small attention-getting stimulus was shown to re-center the point of gaze.

Results

The data consisted of the mean dwell time (DT) per infant on each face. I report here only DT within the faces, recorded by superimposing areas of interest on the faces using

Clearview software (see Figure 2). Areas of interest were generously sized, extending approximately 3° beyond the face, to accommodate head movement of the model as she spoke. Prior to analysis scores were log-transformed to reduce excessive skew in some cells, a common consequence of using infant looking behaviors as a dependent variable; values in the text and figures are taken from raw scores. Infants on average accumulated 135.3 s of total DT on the faces (range = 60.4 – 213.7 s). Thirty-nine of the 5-month-olds included in the analyses completed all 12 trials; two completed 11 trials, and one completed six trials (a complete set of each trial type). Twenty-six of the 3-month-olds completed all 12 trials and seven completed six trials. Preliminary analysis of possible effects of Sex and Order of presentation revealed no significant main effects or interactions that bore on the principal questions of interest; therefore data were collapsed across these variables in the primary analyses¹. In the analyses reported subsequently, statistically significant interactions are followed by simple effects tests as appropriate.

A 2 (Age Group) x 3 (Sound: no speech (silence), ID speech, or AD speech) x 4 (Trial) x 2 (Face: ID vs. AD) mixed ANOVA, with repeated measures on the last three factors, revealed a significant main effect of Age Group, $F(1, 73) = 27.47, p < .001$, partial $\eta^2 = .27$, the result of greater accumulated DT overall in the 5-month-olds ($M = 23.2$ s, $SD = 6.4$) relative to the 3-month-olds ($M = 21.7$ s, $SD = 6.6$), and a significant main effect of Face, $F(1, 73) = 16.72, p$

¹ Preliminary analysis yielded interactions between Order and Trial, $F(9, 177) = 3.40, p < .001$, partial $\eta^2 = .15$, between Order and Sound, $F(6, 188) = 2.82, p < .05$, partial $\eta^2 = .13$, between Order and Sex, $F(3, 59) = 3.75, p < .05$, partial $\eta^2 = .16$, and between Order, Trial, and Age Group, $F(9, 177) = 2.60, p < .01$, partial $\eta^2 = .12$. These interactions appear to have stemmed from effects of ID speech on enhancing general attention, effects most pronounced when ID speech was presented first, in the younger age group, and in boys (the reasons for these latter effects are unclear). There were no reliable effects involving dwell times in ID vs. AD faces.

< .001, partial $\eta^2 = .19$, the result of greater DT overall on the ID face ($M = 25.3$ s, $SD = 8.08$) vs. the AD face ($M = 19.8$, $SD = 6.4$). These main effects were qualified by statistically significant interactions between Trial and Face, $F(3, 219) = 3.57$, $p < .05$, partial $\eta^2 = .05$, and between Sound, Trial, and Face, $F(6, 438) = 6.22$, $p < .001$, partial $\eta^2 = .08$; these effects stemmed from a more pronounced difference in AD face DTs among Sound conditions—higher DTs during AD speech—in the first trial relative to the remaining trials.

There was also a significant Age Group by Sound by Face interaction, $F(2, 146) = 3.15$, $p < .05$, partial $\eta^2 = .04$. This interaction is best interpreted with reference to Figures 3 and 4. Five-month-olds' DT in ID faces was reliably greater than in AD faces, $F(1, 41) = 13.69$, $p < .001$, and this difference was qualified by Sound, $F(2, 82) = 4.82$, $p < .05$: The effect obtained in silence and in ID speech ($ps < .01$, with no reliable difference between the two, $p = .86$) but not in AD speech ($p = .74$). In contrast, analysis of 3-month-olds's DT data revealed a similar difference in overall DT for ID and AD faces, $F(1, 32) = 6.16$, $p < .05$, but this effect was not qualified by Sound, $F(2, 64) = 1.62$, *ns*.

Discussion

Infants at 3 and 5 months looked reliably longer at a model's face recorded when she interacted with her own infant, relative to interactions with her husband, as the faces were shown side-by-side. I interpreted this finding as evidence that young infants prefer infant-directed faces relative to adult-directed faces, perhaps analogous to young infants' preference for ID speech relative to AD speech. At 5 months, infants exhibited a preference for ID faces both in silence and when presented with ID speech that was asynchronous with the facial expressions in the stimulus. However, the ID face preference was modulated by the presence of AD speech, a key result that implies detection of the multimodal match between face and voice. At 3 months, in

contrast, infants' preference for ID faces was not modulated by the qualities of the soundtrack. Instead, the ID face preference was exhibited in all three speech conditions.

These results are consistent with two of my predictions. First, I hypothesized that 5-month-olds would show greater visual attention toward ID faces than AD faces. This hypothesis was supported both by overall higher dwell time on ID faces and by baseline preferences for ID faces in silence. I predicted as well that this baseline preference would be modulated by the presence of speech that is consistent with one of the two faces—either AD or ID—and that this would be revealed by greater dwell time on the face congruent with voice quality. When the 5-month-olds heard AD speech, attention was directed more toward the AD face, implying detection of the match between the AD face and voice. When they heard ID speech, however, attention toward the ID face was not reliably different from baseline. It may be that the ID face and voice were not sufficiently exaggerated relative to AD face and voice to merit increased attention on the infants' part, a possibility consistent with documented changes in the quality of IDS as infants age (e.g., Stern, Spieker, Barnett, & MacKain, 1983). However, adults' ratings for ID face and speech provide evidence that my stimuli were effectively infant-directed, and the infants' clear preference for ID faces confirm this suggestion. I believe instead that the most likely explanation for comparable performance in baseline vs. ID speech conditions is that preferences in both instances were at ceiling, evincing a strong inclination to attend to ID faces whether in silence or accompanied by a compatible soundtrack. Results from 3-month-olds are consistent with those of the 5-month-olds in demonstrating a preference for ID faces. However, ID face preference in the younger infants was not modulated according to the speech condition.

By 3 months, therefore, infants detect and process visual features present in ID faces, and by 5 months, infants detect and process the relationship between dynamic faces and voices that

are associated with adult-infant interactions. To my knowledge, these experiments are the first to document infants' preference for ID faces, and the first to discover an ability to match dynamic faces and voices using the qualities and attributes that specify communicative intent when adults interact with infants. These findings support and extend previous reports of adults' ID behaviors, many of which are multimodal, involving vocal, gestural, and facial expressions presented in synchrony (Gogate, Bahrick, & Watson, 2000). Other studies have identified ID sign language (Masataka, 1992) and ID action (Brand, Baldwin & Ashburn, 2002); these also elicit preference over their AD counterparts (Masataka, 1996; Brand & Shallcross, 2008).

It is unlikely that extensive experience—exposure to infant-directedness—is the sole means by which infants come to prefer ID speech, given that these preferences have been observed at birth (e.g., Cooper & Aslin, 1990). Whether experience of viewing ID faces leads to a preference by 3 months is not known, but such a possibility is consistent with adults' engagement of infant attention via ID behaviors from an early age (Lamb et al., 1987). Alternatively, it is possible that specific features of ID faces, distinct from the defining features of ID speech that might also be present in facial movements (such as repetition, slower pace, and decreased complexity), were responsible for infants' preference. Notably, word counts for each of the 12 face stimuli in my experiment (six ID faces, six AD faces), revealed that the ID faces were slower ($M = 42.17$, $SD = 7.96$) than the AD faces ($M = 55.33$, $SD = 7.09$), $t(22) = 4.28$, $p < .0001$. To examine the possibility that the slower pace of ID faces was responsible for infants' preference for ID faces over AD face, I looked at three trials with similar word counts: The difference in the number of words in these ID and AD faces was less than .33. Fifty-five of the 75 infants in the study produced DT on both faces in all 3 trials, and I examined their preferences in separate analysis. A 2 (Face: ID or AD) x 3 (Speech: no speech, ID speech, AD speech)

within-subjects ANOVA revealed a significant main effect of Face, $F(1, 54) = 29.34, p < .001$, partial $\eta^2 = .35$, indicating reliably greater DT on the ID face ($M = 7.07, SD = 2.79$) than on the AD face ($M = 4.52, SD = 2.02$), and no other statistically significant effects. These data are clear in their indication that preference for ID faces is not solely determined by pacing, because pacing across ID and AD face in these trials was approximately equal.

ID faces are characterized by wider smiles and eye constriction stemming from raised cheeks, presumably resulting from heightened emotional content (Messinger, Mahoor, Chow, & Cohn, 2009). ID faces also exhibit greater eye contact (Brand, Shallcross, Sabatos, & Massie, 2009), and mutual gaze is an attractive stimulus from birth (Farroni, Csibra, Simion, & Johnson, 2002). For my stimuli, the model was instructed to maintain gaze on her partner during the recordings, eliminating differences in eye contact as a possible basis for ID face preference, but the role of more subtle differences between the ID and AD faces in attracting infants' attention remains unknown. Of particular interest would be infants' interpretation of the emotional expressions in both ID and AD faces, assuming that ID faces in general are "happier" (as ID speech may be "happier" than AD speech; Singh, Morgan & Best, 2002), even if, as in the present study, the model interacted with a close family member, exhibiting consistently positive emotional responses. To address the possibility of overlap in infant-directedness and happiness, I obtained adult ratings of "happy" vs. "neutral" in my face and voice stimuli in the same fashion as reported for ratings of infant- vs. adult-directedness (Figure 1). I reasoned that if infant-directedness is undifferentiated from happiness, these ratings would be statistically similar. However, ratings of infant-directedness were consistently higher than ratings of happiness in both ID faces, $t(15) = 3.69, p < .01$, and ID speech ($t(15) = 6.30, p < .001$, implying that infant-directedness and happiness are distinguishable, at least for adults. Recently, I examined 6-

month-old infants' visual preference for silent ID vs. AD faces and introduced controls for positive emotion (Kim & Johnson, 2013). The infants showed no preference for ID faces when both conveyed happiness, but a second group of infants looked significantly longer at AD faces conveying happy emotion over sad ID faces. These findings imply that infants' visual preference for ID faces is mediated, at least in part, by the presence of happy emotion.

ID behaviors may serve an important role as infants learn to discriminate between different emotional states in others. Kaplan, Jung, Ryther, and Zarlengo-Strouse (1996) found that 4-month-olds exhibited increased visual attention for a neutral stimulus following a pairing of ID speech with a static happy face; AD speech had little effect, implying that the infants learned to associate ID speech with positive facial expressions. Four-month-olds also learned associations between "consoling" ID speech and a static sad face, but not a happy face, suggesting that they formed selective associations between distinct emotions conveyed in speech and face (Kaplan, Zarlengo-Strouse, Kirk, & Angel, 1997). ID behaviors, through their arousing effects in infants, could serve a functional role in assisting infants to respond to referential communication directed to them (Senju & Csibra, 2008). Through these interactions, infants become increasingly sensitive to the context-specific nature of speech, facial expression, and other social behaviors, including both ID and AD behaviors, and perhaps come to better understand their own role as social participants.

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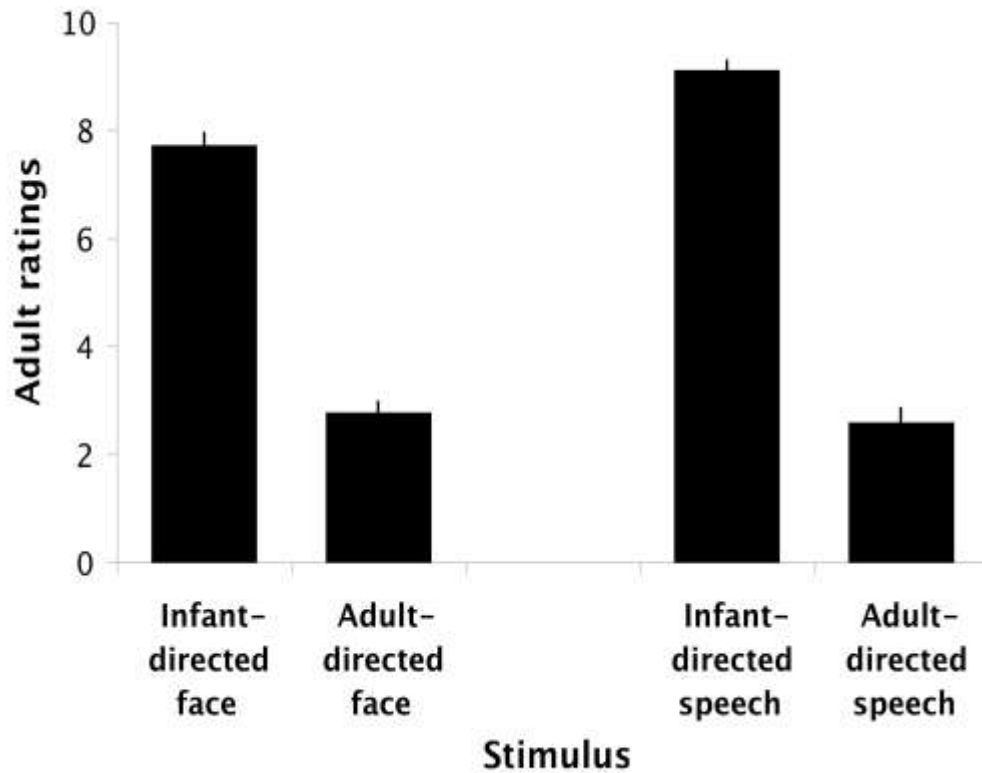


Figure 1. Adult ratings of the six face and four voice stimuli used in Experiments 1 and 2. Faces recorded as the model interacted with her child were rated as more infant-directed, and faces recorded as she interacted with her husband were rated as more adult-directed ($t(15) = 13.25, p < .0001$). The same was true for recordings of the voice ($t(16) = 16.59, p < .0001$).



Figure 2. Examples of infant-directed face (left) and adult-directed face (right). Areas of interest (AOI) within which infant dwell time were recorded.

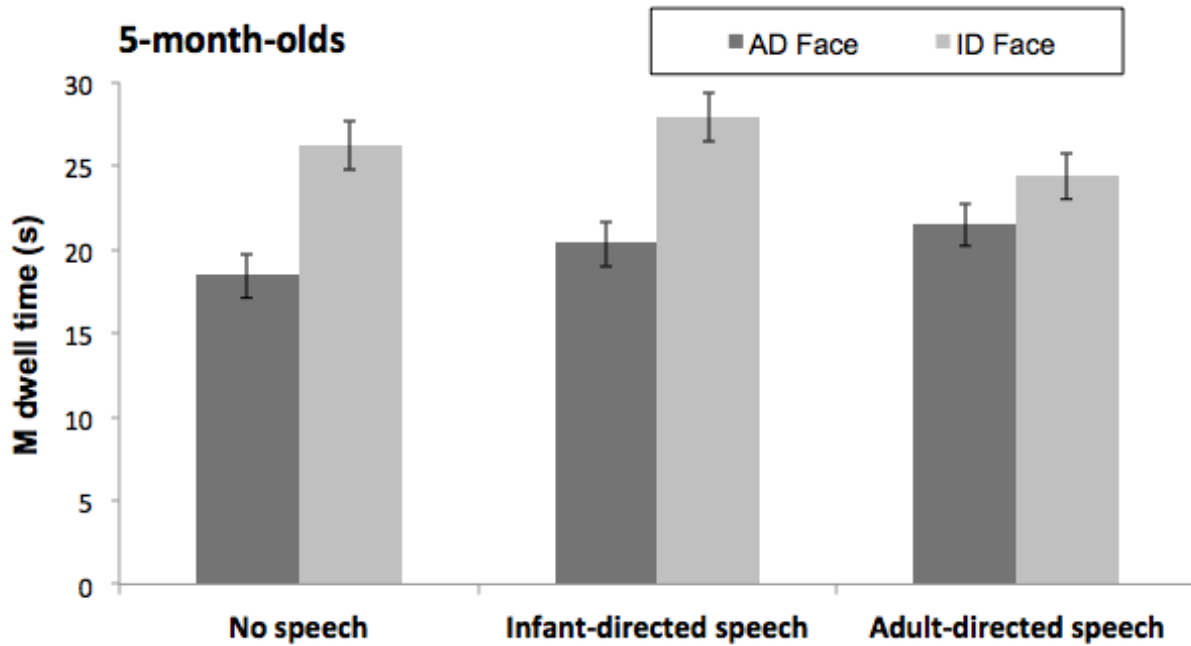


Figure 3. Data from 5-month-olds showing the mean dwell time on each type of face stimulus (ID and AD) under the three speech conditions (no speech, ID speech, and AD speech). Error bars = SEM.

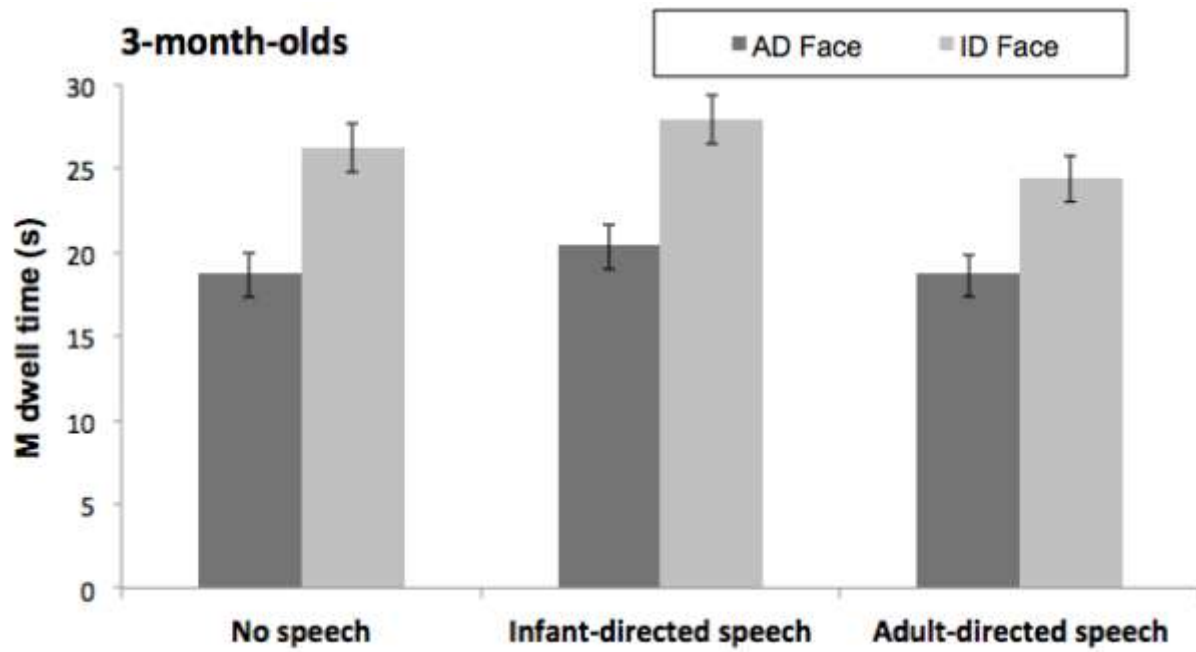


Figure 4. Data from 3-month-olds showing the mean dwell time on each type of face stimulus (ID and AD) under the three speech conditions (no speech, ID speech, and AD speech). Error bars = SEM.

Study 3: Do infants prefer an infant-directed face or a happy face?

The human face has long been considered to be an important source of information available in infants' social environment and plays a critical role in communication between infants and adults (e.g., Bowlby, 1969; Stern, 1974; Vine, 1973). Infants' visual preferences for faces have been well documented and can be observed shortly after birth. For example, newborn infants turn their eyes and heads to track a moving facelike schematic pattern significantly more than they track the same stimulus in a scrambled arrangement (Goren, Sarty, & Wu, 1975; Maurer & Young, 1983). When newborns are shown facelike schematic patterns with features arranged either naturally or unnaturally, they tend to orient to the naturally arranged patterns (Johnson, Dziurawiec, Ellis, & Morton, 1991; Simion, Valenza, Umilta, & Dalla Barba, 1998; Valenza, Simion, Macchi Cassia, & Umilta, 1996). Several hypotheses have been proposed to explain newborn' preference for faces (e.g., Morton & Johnson, 1991; Simion, Valenza, Macchi Cassia, Turati, & Umilta, 2002), but the underlying mechanisms responsible for such phenomena remain unclear.

As young infants become more experienced with faces, primarily by interacting with their caregivers, they develop preferences for particular types of faces. For instance, when presented with a novel male face and a novel female face, 3- to 4-month-old infants prefer looking at the face that matches the gender of their primary caretakers (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002). Similarly, 3-month-old infants prefer to look at faces from their own ethnic group, as opposed to faces from other ethnic groups (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005, 2007). Recently, Kim and Johnson (2012) demonstrated young infants' visual preference for infant-directed (ID) over adult-directed (AD) faces. While infants' listening preference for ID speech has been widely demonstrated (e.g., Cooper & Aslin, 1990;

Fernald, 1985), it was not clear whether infants would show similar responsive behaviors towards ID faces. When 3- and 5- month-old infants were presented with side-by-side displays of dynamic faces produced by a female model, recorded while she interacted with her infant (ID) and her husband (AD) about identical topics, infants as young as 3 months looked longer at the ID faces.

The ID face samples used in the Kim and Johnson (2012) study were perceived to be significantly happier than the AD counterparts according to the adult ratings obtained for each stimulus. This may be because the goal was to obtain ID and AD faces that were as natural and ecologically valid as possible: While interacting with her infant and husband, the female model who produced the stimuli was asked to describe identical topics to both listeners, but was not asked to control the emotional expressions. It is possible, therefore, that differences in affect between ID and AD faces could have contributed to infants' preferences.

To my knowledge, no published study has explored the relation between emotion and “directedness” (infant-directed vs. adult-directed) in ID faces. ID speech, unlike typical AD speech, presents an exaggerated indication of speaker affect, allowing emotion to be easily identified in ID speech (Fernald, 1989, 1992). However, when AD speech contains emotional expressions, the acoustic features of those AD speech samples are similar to those used in typical ID speech (Trainor, Austin, & Desjardins, 2000). Infants' preference for ID speech seems to depend on the level of vocal emotion expressed in speech. Singh, Morgan, and Best (2002) presented 6-month-olds with both ID and AD speech stimuli that were matched for affect, and infants showed no preference for ID speech. When AD speech stimuli conveyed more positive vocal emotion than ID speech, infants preferred listening the AD speech, suggesting that it is the positive emotion conveyed in speech, rather than its infant-directedness, that attracts infants’

attention.

Moreover, infants are thought to be sensitive to emotional expressions in faces early in life (e.g., Fantz, 1961; Jeffrey & Cohen, 1971). Nelson and Horowitz (1983), for example, demonstrated that 2-month-old infants discriminate a happy face from a neutral face presented in a holographic stereogram. Similarly, 3-month-olds can discriminate happy faces from sad and surprise expressions (Young-Browne, Rosenfeld, & Horowitz, 1977) as well as smiling from frowning facial expressions in still photographs (Barrera & Maurer, 1981). Finally, Soken and Pick (1999) investigated how infants respond to positive and negative dynamic facial expressions using a preferential looking paradigm, and found that 7-month-olds were sensitive to multiple kinds of emotional expression, discriminating among happy, interested, angry, and sad expressions.

Therefore, in a pair of experiments, I investigated the role of facial emotion on infants' preference for ID faces by examining infants' responses to faces varying on two dimensions: emotion and directedness.

Experiment 1

Experiment 1 examined the possibility that infants' preference for ID faces is attributable to the positive emotion present in ID faces. I presented infants side-by-side displays of two types of dynamic, silent faces: happy ID faces and happy AD faces. Because the positive emotion in ID speech contributes to infants' preference for the particular type of speech and because infants are known to be sensitive to positive emotion in facial expressions, I hypothesized that infants would show no preference when both ID and AD faces were equated on happiness.

Method

Participants. Twenty-two full-term 6-month-olds (12 girls, 10 boys, M age = 6.0

months, range = 5.4-6.4 months) were recruited from birth records provided by the county. Parents were first sent a letter of invitation to participate in the experiment; interested parents returned a postcard and were later contacted by telephone. Six additional infants were observed but excluded from the analysis due to fussiness (2) or equipment failure/experimenter error (4). Parents were provided with a small gift for their infants but were not paid for participation.

Materials. Infants viewed a pair of videotaped events. Each event showed a woman's face as she engaged in a live face-to-face interaction with a member of her own family—either her husband or her 18-month-old infant. The model and family members viewed a video monitor showing the person with whom they were conversing during the live interaction (cf. Murray & Trevarthen, 1985). One woman served as the model for all stimuli. The model was asked to describe the same happy events to both infant and husband. Prior to recording sessions, the model was given a few minutes to recollect happy memories (e.g., the birth of her child), then was asked to describe the event to both listeners on separate occasions for approximately the same duration. The recordings of the model's facial expressions were parsed into multiple 10-second segments to be used as visual stimuli.

The segments were also rated by 16 undergraduate students for directedness and emotion. The directedness of face clips was rated as infant- or adult-directed using an 11-point-Likert scale, a value of 5 denoting a face clip as “definitely produced when she was interacting with an infant” and a value of -5 as “definitely produced when she was interacting with an adult.” An 11-point-Likert scale was also used to rate the face clips as happy or sad, a value of 5 denoting a face clip as “very happy” and a value of -5 as “very sad.” In general, the ID face clips were judged to be infant-directed and AD face clips were judged as adult-directed, $t(15) = 5.814$, $p < .001$, but the emotion ratings of both face types were judged to be more similar, $t(15) = 1.389$,

$p = .185$, which confirmed that for adults at least, the ID and AD face samples were seen as portraying happiness (see Figure 1).

A total of 12 face segments were selected to create six side-by-side stimuli with Adobe Premiere; six face clips with the highest scores in directedness (the most ID-like) and the highest in emotion (the happiest) were selected as happy ID faces ($M = 1.26$, $SD = .92$), and six face clips with the lowest scores in directedness (the most AD-like) and the highest in emotion (the happiest) were selected as happy AD faces ($M = -1.98$, $SD = 1.73$). Each visual stimulus measured 25 x 22.5 cm (23.5 x 21.2° visual angle) and was separated by a gap of 1.5 cm (1.4°). Each face measure approximately 14 x 10.5 cm (13.3 x 10.0°). Moreover, the ID face clips generally contained more up-and-down movements than the AD counterparts, but both faces were labeled for the most part. I also drew the areas of interests (AOIs) generously not only to accommodate movement of the model during the interaction, but also to accommodate possible eye tracker inaccuracies. See Figure 2 for an example.

Procedures. Eye movements were recorded with a Tobii T60 XL eye tracker at 60 Hz with a spatial accuracy of approximately .5-1°. Infants were tested individually, seated on a parent's lap approximately 60 cm away from a 24-inch computer monitor. To calibrate each infant's point of gaze, a dynamic target-patterned ball undergoing repeated contraction and expansion around a central point was presented briefly at five locations on the screen (the four corners plus the center) as the infant watched. The Tobii eye tracker provides information about calibration quality for each point; if there were no data for one or more points or if calibration quality was poor, calibration at those points was repeated. Prior to each trial a small attention-getting stimulus was briefly shown on the screen to reorient infants' point of gaze to the center of the screen. On each trial, both happy ID and AD faces were presented side-by-side for 10 s.

Each infant was exposed to a total of 12 trials; six unique sets of stimuli were presented twice, ID faces were on the left for half of the trials, and on the right for the other half of the trials. The order of stimulus presentation was randomized.

Results and Discussion

Every infant who participated in this experiment completed all 12 trials. On average, infants contributed an average of 80.08 seconds of total dwell time on the faces (range = 48.88-119.14). Infants produced significantly higher total dwell time in the first six trials ($M = 43.59$, $SD = 10.25$) than in the last six trials ($M = 36.49$, $SD = 12.28$), $t(21) = 2.694$, $p = .014$. However, due to high variability of raw dwell time between individuals, the raw dwell time was converted to the proportion of dwell time on the ID and AD faces, which was my index of visual preference. Despite producing more dwell time in the first six trials than the last six trials, the mean proportion of dwell time on the ID and AD faces was equivalent between the first and the last six trials, $t(21) = .080$, $p = .937$.

The mean proportion of dwell time on each face was computed per infant prior to analysis. Although ID and AD faces made up approximately 25% of the total surface area of the screen, infants on average fixated within the faces approximately 90% of the time. Thus, only eye movements that took place within the faces, recorded by the AOIs superimposed on the faces using Tobii Studio software (see Figure 2), are reported.

The results of Experiment 1 are shown in Figure 3. A paired-samples t -test revealed no significant difference in dwell time between happy ID faces and happy AD faces, $t(21) = 1.611$, $p = .122$. Infants' average proportions of dwell times were .471 for happy ID faces ($SD = .085$), and .529 for happy AD faces ($SD = .085$). As predicted, infants showed no preference for ID faces when the positive emotion of ID and AD faces were held constant, suggesting that the

positive emotion in faces may have contributed to infants' preference for ID faces in the Kim and Johnson study (2012). The infant-directedness, above and beyond its emotional content, did not draw infants' attention, even though ID faces were perceived to be undoubtedly *infant*-directed according to the adult ratings.

Experiment 2

Experiment 1 shows that infants' preference for ID faces over AD faces does not extend to scenarios in which both faces express the same positive emotion, suggesting that infant-directedness alone does not elicit infants' visual preference for ID faces. Moreover, it also highlights the importance of positive emotion in faces, such that the positive emotion conveyed in faces may play a significant role in attracting infants' attention. In Experiment 2 I further investigated this issue by showing infants the faces that are the opposite of each other on both emotion and directedness: *happy* faces directed to *adults* and *sad* faces directed to *infants*.

I reasoned that preferential looking toward happy AD faces would suggest infants' greater affinity for the positive emotion in faces than for the infant-directedness, whereas preferential looking toward sad ID faces would suggest infants' greater affinity for the infant-directedness than for the positive emotion. Alternatively, a preference for sad ID faces over happy AD faces could also indicate a negativity bias, a tendency to attend more to the negative emotion over the positive emotion (see Vaish, Grossmann, & Woodward, 2008). Although it has been demonstrated that infants show a negativity bias (e.g., de Haan, Belsky, Reid, Volein, & Johnson, 2004; Kotsoni, de Haan, & Johnson, 2001; Ludemann and Nelson, 1988; Nelson and Dolgin, 1985), such a bias is more prevalent in infants older than 7 months (see Vaish, Grossmann, & Woodward, 2008). In contrast, infants younger than 6 months seem to prefer the positive emotion over the negative emotion (e.g., LaBarbera, Izard, Vietze, & Parisi, 1976; Wilcox &

Clayton, 1968).

Method

Participants. Twenty-two full-term 6-month-old infants (11 girls, 11 boys, M age = 5.9 months; range = 5.4-6.5 months) were recruited from birth records provided by the county, using the same procedures as described in Experiment 1. None of the infants who participated in Experiment 1 participated in Experiment 2. Six additional infants were observed but excluded from the analysis due to fussiness (4) or equipment failure/experimenter error (2).

Materials and Procedures. Materials and procedures were identical to those used in Experiment 1 with one exception: happy ID faces were replaced by sad ID faces. To obtain sad face stimuli, the same model was asked to talk about a few particularly sad topics (e.g., passing of her grandfather) to her child. After segmenting the recordings into multiple 10-second clips, they were rated by the same group of undergraduate students to confirm infant-directedness and sadness. As shown in Figure 1, the ID and AD face clips were judged to be significantly different in directedness, $t(15) = 3.099$, $p = .007$, and the emotion ratings of both face types were also judged to be different, $t(15) = 12.321$, $p < .001$.

Results and Discussion

Every infant participated in this experiment completed all 12 trials, and infants on average contributed an average of 77.65 seconds of total dwell time on the faces (range = 40.56-106.83). As in Experiment 1, infants produced significantly higher total dwell time in the first six trials ($M = 43.14$, $SD = 9.57$) than in the last six trials ($M = 34.51$, $SD = 13.18$), $t(21) = 3.842$, $p = .001$. Despite producing more dwell time in the first six trials than the last six trials, however, the mean proportion of dwell time on the ID and AD faces was equivalent between the first and the last six trials, $t(21) = .134$, $p = .895$.

The results of Experiment 2 are shown in Figure 4. A paired-samples t-test revealed significantly longer dwell times on happy AD faces than on sad ID faces, $t(21) = 2.223, p = .037$. Infants' average proportions of dwell times were .531 for happy AD faces ($SD = .066$) and .469 for sad ID faces ($SD = .066$). Infants were drawn more to happy AD faces, therefore, presumably because of the expressions of positive affect. In contrast, ID faces were not as effective in attracting infants' attention when conveying negative affect.

General Discussion

In the present study, 6-month-old infants showed no preference for ID faces over AD faces when both faces were matched for emotional content (Experiment 1), and they looked reliably longer at AD faces expressing happiness relative to ID faces expressing sadness (Experiment 2). Taken together, I tentatively interpret these results as evidence that happiness conveyed in faces, rather than the infant-directedness of faces, contributes to infants' visual preference for ID faces. Moreover, the pattern of results found in these studies closely resembles how 6-month-old infants respond to ID and AD speeches of varying vocal emotion (Singh et al., 2002). Expressions of emotion in ID communicative behaviors, whether speech or facial expressions, appear to play a principal role capturing infants' attention. To my knowledge, this study is the first to discover a key component of ID faces to which infants respond.

I was interested in infants' interpretation of the emotional expressions in both ID and AD faces. Evidence suggests that spontaneous ID speech is "happier" than AD speech (Singh et al., 2002; Trainor et al., 2000), and similarly, spontaneous ID faces are perceived happier than AD faces (Kim & Johnson, 2012). However, the ID and AD face stimuli used in Experiment 1 were rated equally happy (see Figure 1). Although controlling for emotion was necessary to tease apart the effect of the infant-directedness from that of happy expressions, in doing so, the ID and

AD faces became very similar. Indeed, the differences between ID and AD faces appear to be more subtle when both express the same emotion: ID faces are characterized by wider smiles and eye constriction stemming from raised cheeks, presumably resulting from heightened emotional content (Messinger, Mahoor, Chow, & Cohn, 2009). Such descriptions of ID faces closely resemble happy faces in general. Although engaging in more face-to-face interactions may help infants better discriminate ID faces from merely happy faces, such an ability may be rather challenging to achieve given that both faces share many perceptual similarities. Thus, the absence of preference shown in Experiment 1 poses a possibility that infants might not be able to discriminate the faces solely on the basis of the directedness when emotion is held constant. A further investigation on how infants respond to a comparison between sad ID faces and sad AD faces would provide more insight on this issue.

On the other hand, infants looked reliably longer at happy AD faces to sad ID faces in Experiment 2, suggesting that infants had no problem discriminating between the faces that differed both emotion and directedness. In particular, it appeared that the difference of emotion between the ID and AD faces was more apparent than that of directedness (see Figure 1). It is possible that the directedness of the faces became less recognizable once the speech is lost from the videos, which led the infants to simply respond to the emotions expressed in the faces regardless of their directedness. This view explains why the preference for ID faces over AD faces did not persist when controlling for emotion (Experiment 1), and why infants preferred *happy* AD faces over *sad* ID faces (Experiment 2). However, according to the adult ratings on the face stimuli, the absence of speech from the faces seemed to have affected only the directedness of ID faces expressing sadness; while happy ID faces were rated as unequivocally infant-directed, sad ID faces were rated slightly adult-directed, despite the fact that both were

recorded from the same mother-infant interactions. Therefore, it is more likely that infants responded to the emotional expressions of the faces in Experiment 2 because sad ID faces failed to convey the proper infant-directedness to infants while both faces expressed clearly contrasting emotions. I believe that happiness is an essential characteristic of "infant-directedness."

Nevertheless, the notion of "infant-directedness," the characteristic, intrinsic properties of ID communicative behaviors itself warrants further investigation. Besides emotional content, there are other properties of infant-directedness that have yet to be systematically examined (e.g., slower pace, more repetition, and decreased complexity). Interestingly, when adults rated the face and voice stimuli, few had difficulty distinguishing ID faces and happy AD faces. Many reported that they used a slower tempo and/or more repetitions as cues to identify something as infant-directed. Thus, a more objective analysis of infant-directedness coupled with systematic investigations of infants' sensitivity to the individual property of infant-directedness will advance our knowledge regarding infant-directedness and its relation to multiple kinds of infant-directed communications. Nevertheless, it is unclear how exactly infants perceived the face stimuli used in the present study.

Finally, ID behaviors may serve an important role in infants' discrimination of emotional states in others. Kaplan, Jung, Ryther, and Zarlengo-Strouse (1996) found that 4-month-olds exhibited increased visual attention for a neutral stimulus following a pairing of ID speech with a static happy face; AD speech had little effect, implying that the infants learned to associate ID speech with positive facial expressions. Four-month-olds also learned associations between "consoling" ID speech and a static sad face, but not a happy face, suggesting that they formed selective associations between distinct emotions conveyed in speech and face (Kaplan, Zarlengo-Strouse, Kirk, & Angel, 1997). ID behaviors, through their arousing effects in infants, could

serve a functional role in assisting infants to respond to referential communication directed to them (Senju & Csibra, 2008). Through these interactions, infants become increasingly sensitive to the context-specific nature of speech, facial expression, and other social behaviors, including both ID and AD behaviors, and perhaps come to better understand their own role as social participants.

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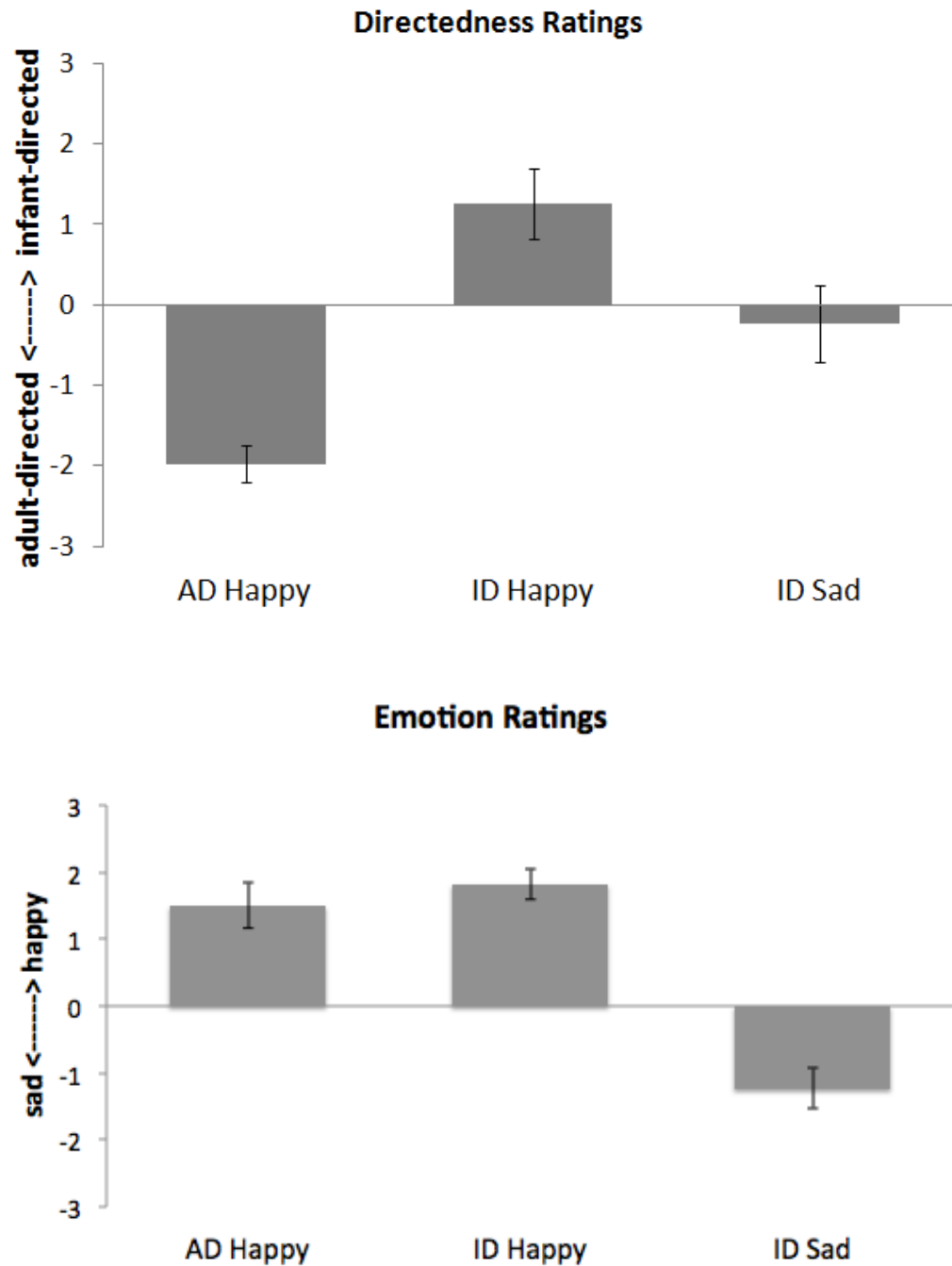


Figure 1. Results showing adults' ratings of directedness (adult- vs. infant-directedness) and emotion (happy vs. sad) for all faces shown to infants in Experiments 1 and 2. Error bars = *SEM*.



Figure 2. Examples of happy infant-directed face (left) and happy adult-directed face (right), and areas of interest within which infant scanning patterns were recorded.

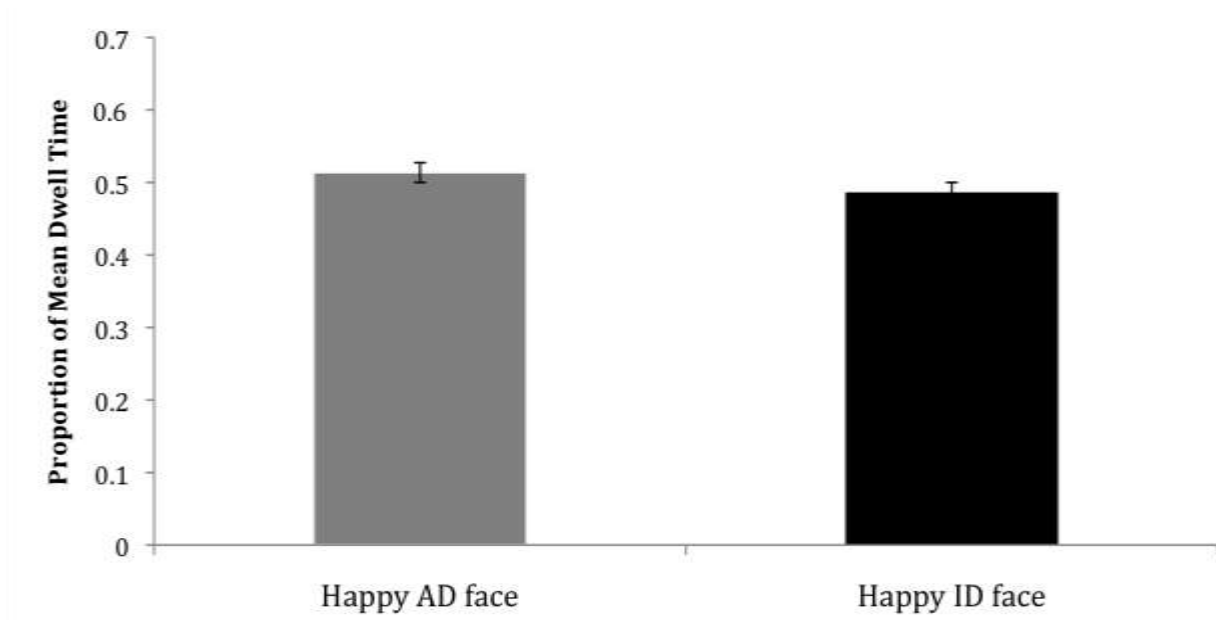


Figure 3. Data from 6-month-olds in Experiment 1, showing the proportion of mean dwell time on each type of face stimulus (happy AD face and happy ID face). Error bars = *SEM*.

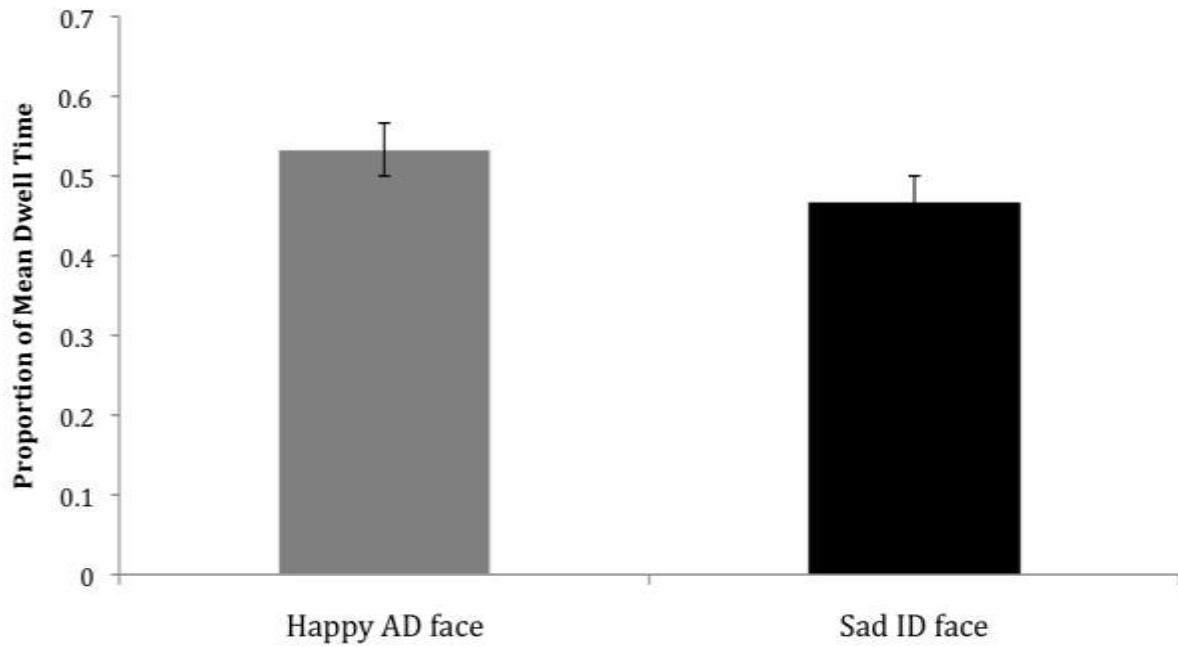


Figure 4. Data from 6-month-olds in Experiment 2, showing the proportion of mean dwell time on each type of face stimulus (happy AD face and sad ID face). Error bars = *SEM*.

Study 4: The Effect of Happiness on the Other-Race Effect in 9-month-old Infants

The visual environment surrounding infants is dominated with faces. Faces are arguably one of the most seen visual stimuli in infants' everyday lives. Moreover, it can be argued that we may be born with a bias to attend to faces as demonstrated by newborns' preference for face-like shapes over other non-face visual stimuli despite their minimal exposure to faces (Goren, Sarty & Wu, 1975; Johnson & Morton, 1991; Maurere & Young, 1983; Valenza et al., 1996; Turati Simion, Milani, & Umilta, 2002). More importantly, however, recent emerging neurological and behavioral evidences suggest that the way infants process faces becomes specific over the first year of life as they encounter certain types of faces much more frequently than others (Nelson, 2003; Simion, Leo, Turati, Valenza, & Dalla Barba, 2007). For example, numerous studies have shown infants' reliable preference for maternal faces over non-maternal female faces (e.g., Bushnell, Sai, & Mullin, 1989; Field, Cohen, Garcia, & Greenberg, 1984; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995). Such phenomenon is understandable because most infants spend the majority of their waking hours interacting face-to-face with their mother, especially in the first several months. Similarly, Rennels and Davis (2008), in their observation of infants and their social environment in the first year of life, showed strikingly large discrepancies in the race, sex, and age of faces infants experience in their first year of life. Specifically, infants are much more experienced with the faces of their primary caregivers, females, and other own-race individuals (Rennels & Davis, 2008).

These notable discrepancies in infants' early experiences with faces appear to quickly influence the way they process faces. For example, as early as 3 months, infants show signs of heightened sensitivity to several types of social information available in faces, such as species (Pascalis, de Haan, & Nelson, 2002), gender (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002), and

race (Kelly, Quinn, Slater, Lee, Gibson, Smith, et al., 2005; Kelly, Liu, Ge, Quinn, Slater, Lee, et al., 2007). Moreover, 3-month-old infants are shown to prefer own-race faces over other-race faces (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly, Ge, Liu, Quinn, Slater, Lee, et al., 2007). Despite such preference for own-race faces, 3-month-old Caucasian and Chinese infants are able to individuate own-race faces as well as other-race faces (i.e., African, Middle Eastern, and Chinese; Kelly et al., 2007; Kelly et al., 2009). However, such flexibility in their perceptual system diminishes after undergoing extensive experience with own-race faces and limited exposure to other-race faces. As a result, infants beginning at 6 months and by 9 months can discriminate faces within their own racial group, but cannot discriminate faces within other racial groups, a phenomenon known as the ‘other-race effect’ (ORE; Malpass & Kravtiz, 1969).

As described in previous studies, human faces frequently communicate emotional information, and recognizing emotional expressions of others appears to be adaptive (Darwin, 1872; Rusell, 1994). For instance, the ability to quickly recognize expressions of fear in others’ faces can be advantageous to one’s survival. Similarly, recognizing whether their caregiver is happy or angry can be very important to infants who must rely on the caregivers for their survival. Although a few studies suggest that newborns may be able to discriminate between different facial expressions of emotion (e.g., Field, Cohen, Garcia, & Collins, 1983; Field, Woodson, Greenberg, & Cohen, 1982), it is unlikely that newborns can reliably discriminate facial expressions because of their visual acuity, contrast sensitivity and ability to resolve high-spatial-frequency information are very limited early in life (Banks & Salapatek, 1983). Moreover, infants younger than 2 months do not seem to attend to internal features of faces, which reveal important emotional information (Bushnell 1979; Maurer & Salapatek, 1976).

However, infants quickly learn to discriminate between facial expressions, perhaps due to their continual exposure to certain facial expressions, most notably, happy faces. Three-month-old infants begin to show signs of discriminating between happy and surprised faces (Young-Browne, Rosenfeld, & Horowitz, 1978), and happy from angry faces (Barrera & Maurer, 1981). By 4 months, infants exhibit greater recognition of happy (or smiley) facial expressions compared to facial expressions of other emotions. For example, when presented with happy, angry and neutral faces, infants as young as 4 months preferred happy faces over the other two faces, but failed to show recognition of either angry and neutral faces (LaBarbera, Izard, Vietze, & Parisi, 1976). Taken together, infants are able to recognize happy faces better than other emotional expressions, probably because they occur much more frequently than the others in infants' social environment. Conversely, infants' lack of experiences with angry or neutral faces seems to be attributable to their inability to discriminate between those particular expressions.

Infants are vastly experienced with both own-race faces and happy faces. However, studies demonstrating the ORE in infants (e.g., Bar-Haim et al., 2006; Kelly et al., 2007; 2009) either used only neutral faces or failed to systematically manipulate emotions expressed by faces. Although these studies provide valuable insight regarding the role of infants' experience in the development of infant face perception, the results might not accurately reflect the reality because infants seldom encounter neutral faces during everyday interactions with their caregivers. Moreover, even though neutral faces are supposed to portray the absence of emotion, it is questionable if infants actually perceive them as emotionless faces. Conversely, infants are very familiar with happy faces compared to many other facial expressions of emotion including neutral faces, thus, it is plausible that recognizing a familiar emotion in unfamiliar faces may alter the way infants perceive those faces.

Therefore, in the present study I examined how familiar facial expressions (i.e., happy faces) would influence the way infants perceive own- and other-race faces. Given that recognizing social information conveyed through faces is a fundamental step for infants in becoming expert face perceivers and competent social beings, an accurate and more realistic description of how infants perceive race and emotion in faces will provide a fuller understanding regarding the role of experience in infancy.

A slightly modified visual search paradigm was used to determine the infants' ability to discriminate between faces. Both the target and distractors were faces displaying the identical race and emotion (i.e., own-race happy faces, own-race neutral faces, other-race happy faces, other-race neutral faces). However, while the distractors were repetitions of the same face, the target face portrayed an individual that was different from the rest. Infants' eye movements and the precise time taken to find target faces were recorded with an eye tracker.

There were three hypotheses regarding the effects of the face race, the face emotion, and the interaction of the two on infants' ability to discriminate faces. First, I hypothesized that infants would show better and faster discrimination between own-race faces than between other-race faces, regardless of the face emotion. This hypothesis is consistent with previous findings that showed infants' poor discrimination ability between other-race faces compared to that between own-races faces (i.e., ORE). Second, I hypothesized that infants would show better and faster discrimination between happy faces than between neutral faces, regardless of the face race. This hypothesis stems from previous findings demonstrating infants' ability to discriminate happy faces than faces expressing other emotions. Finally, I hypothesized the interaction between race and emotion such that just as infants would discriminate own-race faces regardless of the face emotion, infants would also discriminate other-race faces, but only when they display

happiness. I predicted that the familiar emotion (i.e., happiness) displayed in other-race faces would facilitate infants' ability to discriminate unfamiliar faces.

Method

Participants

Sixteen mono-racial Caucasian 9-month-olds (12 males; *M* age = 9.29 months, age range = 8.7-9.5 months) were recruited from birth records provided by the Los Angeles County. All infants were full term and with no developmental delays. Parents were first sent a letter of invitation to participate in the experiment; interested parents returned a postcard then were contacted by telephone subsequently. Six additional infants were observed but excluded because of fussiness (3) or equipment failure/experimenter error (3). All parents were provided with a small gift for their infants for participation.

Stimuli

All of the faces were taken from the NimStim Set of Facial Expressions (Tottenham et al., 2009). Four different Caucasian female models and four different Asian female models were selected, and each model produced two photos by exhibiting happy and neutral facial expressions. The differences in skin color information between Caucasian faces and Asian faces were minimized by converting all photos into grayscale. Faces varied in race (Caucasian or Asian) and emotion (Happy or Neutral), which created four face categories: Caucasian-Happy, Caucasian-Neutral, Asian-Happy, and Asian-Neutral. Each face category consisted of four faces produced by four different individuals.

Figure 1 shows how the face set stimuli were constructed. Experiment Builder, propriety software for SR Research eye trackers, was used to create a total of 48 face set stimuli, 12 sets per each of four face categories (i.e., Caucasian-Happy, Caucasian-Neutral, Asian-Happy, and

Asian-Neutral). Each face set stimulus consisted of four faces arranged on a white background in a square formation so that they were equally distanced from the center of the screen (see Figure 1). All four faces in a face set stimulus displayed the same race and emotion. Whereas three of the four faces were identical photos (i.e., distractors), one face differed from the rest (i.e., the target) as it portrayed another individual from the same face category as the distractors. The areas of interest (AOIs) were superimposed on all faces to provide precise measures of infants' eye movements on the faces (see Figure 1). Each face set stimulus measured 34 x 30 cm (31.7 x 28.1° visual angle), and each face measured 10.2 x 11.3 cm (9.7 x 10.8°).

The faces were randomly chosen for each face set stimulus and were controlled for frequency; of the four faces that belonged to the same face category, each face was presented three times as the distractor face and three times as the target face to control for the total number of times they were presented to infants. The location in which the target face appeared was also randomized throughout the study with two constraints: the target face was presented on all four corners of the screen for the same number of times while never appearing in the same location more than two consecutive trials. The presentation order was also randomized for every infant.

Procedure

Infants were tested individually, seated on a parent's lap approximately 60 cm away from a 22-inch widescreen monitor surrounded by black curtains. The lights in the experimental room were dimmed and the only source of illumination came from the monitor. A SR Eyelink 1000 eye tracker recorded infants' eye movements at 500 Hz with a spatial accuracy of .5°.

To calibrate each infant's point of gaze, a dynamic target-patterned ball undergoing repeated contraction and expansion around a central point was presented briefly at five locations on the screen (the four corners plus the center) as the infant watched. The SR Eyelink eye

tracker continued until all points were accurately calibrated, then performed an automated validation process to confirm the quality of the calibration on all five points. Calibration was followed immediately by presentation of face set stimuli as described previously. Prior to each trial a small attention-getting stimulus with sounds was briefly presented in the center of the screen in order to reorient infants' attention before advancing to the next trial. Each infant was presented with a total of 48 trials, each trial lasting up to four seconds. Alternatively, fixating at the target face for 700ms was counted as “finding” the target, thus triggered the immediate termination of the trial.

Results

For each infant, the data consisted of two dependent measures representing his or her discriminatory ability: success rate and latency. First, success rate was computed by the proportion of successful trials (i.e., trials in which the target face was found within four seconds) out of the total number of trials presented. Second, latency was computed by the average time taken to find target faces in successful trials.

Success Rate.

Figure 2 illustrates the mean success rate across all 16 infants. On average, infants viewed 46.25 trials (range: 36-48, $SD = 3$) out of 48 trials and succeeded in finding the target face 43% of the time (range: .30-.54, $SD = .06$). In all four face categories, infants found the target face reliably better than chance, $t_s(15) > 2.60$, $p < .02$. Preliminary analysis including sex of infants yielded no significant main effect of sex nor any interactions involving sex, $F_s < .587$, *ns*. Therefore data were collapsed across sex in subsequent analyses.

A 2 (Race: Caucasian, Asian) x 2 (Emotion: happy, neutral) within-subject analysis of variance (ANOVA) revealed no significant main effect of Race, suggesting that infants did not

differ in their rate of finding target faces in Caucasian face sets ($M = .409$, $SD = .11$) and in Asian face sets ($M = .445$, $SD = .10$), regardless of the emotion of the faces, $F(1,15) = .807$, $p = .38$. There was a significant main effect of Emotion, indicating that infants found target faces reliably better in happy face sets ($M = .472$, $SD = .11$) than in neutral face sets ($M = .382$, $SD = .10$), regardless of the race of the faces, $F(1,15) = 5.293$, $p = .036$, partial $\eta^2 = .26$. Finally, there was no significant interaction between race and emotion, $F(1,15) = .170$, $p = .69$.

Latency.

Figure 3 depicts the mean latency across all 16 infants. On average, infants took 1912.17 milliseconds ($SD = 192.61$) to find the target face. Preliminary analysis including sex of infants yielded no significant main effect of sex nor any interactions involving sex, $F_s < .542$, *ns*. Therefore data were collapsed across sex in subsequent analyses.

A 2 (Race: Caucasian, Asian) x 2 (Emotion: happy, neutral) within-subject ANOVA yielded no significant main effect of Race, suggesting that there was no difference in the amount of time taken to find target faces in Caucasian face sets ($M = 1883.08$, $SD = 314.91$) and in Asian face sets ($M = 1941.26$, $SD = 304.20$), regardless of the emotion of the faces, $F(1,15) = .230$, $p = .64$. There was a significant main effect of Emotion, indicating that significantly less time was needed to find target faces in happy face sets ($M = 1810.42$, $SD = 168.76$) than in neutral face sets ($M = 2013.91$, $SD = 320.06$), regardless of the race of the faces, $F(1,15) = 5.840$, $p = .029$, partial $\eta^2 = .28$. However, Finally, there was no significant interaction between race and emotion, $F(1,15) = 1.357$, $p = .26$.

Discussion

Nine-month-old Caucasian infants successfully discriminated between individual faces within their own racial group (i.e., Caucasian faces) and within unfamiliar racial group (i.e.,

Asian faces). Moreover, the same infants discriminated between happy faces more often and more quickly than between neutral faces, regardless of the race of those faces.

Contrary to my prediction regarding the face race, I found that 9-month-old Caucasian infants in the present study did not exhibit signs of the ORE, at least when tested in the visual search paradigm. The success rate data suggest that Caucasian infants were just as good at discriminating between Asian faces as at discriminating between Caucasian faces. Similarly, the latency data suggest that Caucasian infants were able to find more quickly the face that was different from the rest. Interestingly, this particular finding is inconsistent with a body of evidence demonstrating the ORE in 9-month-old infants of various racial backgrounds (e.g., Bar-Haim et al., 2006; Kelly et al., 2007; 2009).

Such discrepancies in findings can be attributable to the differences in the paradigms employed to examine the ORE in infants. The habituation paradigm is a popular and a reliable method that measures infants' looking time to test infants' discrimination, preference, and categorization in various domains of visual, auditory, and multimodal stimuli. For the last several decades, hundreds of studies have used the habituation paradigm to investigate many interesting questions regarding infants' ability to discriminate. However, the habituation paradigm requires infants' ability to remember the familiar stimulus prior to testing whether or not infants can distinguish a novel stimulus from the stimulus they are already familiar with. In studies examining the ORE in infants, infants must be continuously exposed to the same other-race face over a prolonged period of time before being tested with the same face and a novel other-race face. Therefore, it can be argued that, rather than differentiating multiple examples of other-race faces, an infant who participated in the habituation paradigm might actually be comparing the novel other-race face with his or her memory of the familiar other-race face.

The visual search paradigm tests the observer's ability to detect a discrepant element in visual stimuli (Treisman & Souther, 1985). The visual search paradigm has also been used, albeit limited to few domains of visual stimuli, to demonstrate infants' discriminatory ability as young as 3 months of age (e.g., Colombo, Ryther, Frick, & Gifford, 1995; Rovee-Collier, Hankins, & Bhatt, 1992). The key feature of the visual search paradigm, as it pertains to the present study, is that it does not rely on infants' memory of the familiar stimulus when testing their discriminatory ability because all of the faces that needed to be discriminated are presented together at the same time. Therefore, infants are able to detect the face that is different from the rest without having to remember it first.

Furthermore, while both methods are used to determine the ORE in infants, it can be argued that the visual search paradigm is actually measuring a slightly different, yet highly related, type of face processing than the habituation paradigm does. It is true that infants in both paradigms are presented with multiple instances of an other-race face that needs to be distinguished from another other-race face. However, a close look at the paradigms reveals a critical difference in the way the first type of face is presented multiple times. While the habituation paradigm presents one face for several times in a serial manner, the visual search paradigm simultaneously presents several instances of that same face, along with a different face. A close comparison can be made with a real-world example. While adults struggle greatly with distinguishing faces of individuals from unfamiliar racial group, doing so should be easier if all of the individuals that need to be distinguished appeared simultaneously. Conversely, it would be much more challenging to judge whether or not the individual you are encountering now is different from whom you saw yesterday.

As predicted, 9-month-old Caucasian infants showed better and faster discrimination of happy faces than neutral faces, regardless of the face race. This particular finding is expected because infants are more familiar with happy faces than faces expressing any other emotions. Around 3 months, infants can reliably discriminate happy faces from facial expressions of other emotions (e.g., Barrera & Maurer, 1981; LaBarbera, Izard, Vietze, & Parisi, 1976; Young-Browne, Rosenfeld, & Horowitz, 1978). Moreover, infants as young as 5 months can recognize, discriminate, and categorize happy facial expressions (Bornstein & Arterberry, 2003). Similar to the phenomenon of the ORE, it is plausible to argue that infants' ample experience with happy faces, and the lack of experience with neutral faces, allowed them to be better able to individuate facial expressions conveying the familiar emotion.

Furthermore, the present findings indicate an interesting asymmetry such that infants differentiated happy faces better than neutral faces while being equally good at discriminating own- and other-race faces. Albeit inconclusive, it appears that infants are better at utilizing the familiar emotion (i.e., happiness), than the familiar race, as a cue to differentiate faces. This is puzzling given that infants undergo equally abundant experiences with both own-race faces and happy faces. However, unlike race, which is communicated in a stable and permanent fashion, emotions expressed in faces are communicated transiently; whereas one individual rarely presents multiple racial groups at different times, one can show several facial expressions depending on his or her emotional state. Therefore, the asymmetry found in the present study is probably not due to the different amount of experiences infants had with own-race and happy faces. Rather, the dynamic and temporary nature of emotions may influence infants to perceive the emotional expressions of a face before processing other types of information (e.g., race, gender, age) communicated by the same face.

In sum, the present study is the first to use the visual search paradigm to examine the effect of happiness on the ORE in 9-month-old infants. Contrary to previous findings, 9-month-old Caucasian infants may not be susceptible to the ORE when they do not need to rely on memory to discriminate faces. To reconcile the disparity in findings, two future studies are proposed. First, the same or slightly modified visual search paradigm can be used to test the ORE in adults to confirm the validity and the sensitivity of the current method in examining the ORE in infants. Second, testing infants at different, perhaps older, age groups are warranted to provide clearer understanding regarding the alternative origin and the developmental trajectory of the ORE throughout infancy. More importantly, the present finding regarding 9-month-olds' ability to utilize a familiar emotion to individuate faces further suggests that there may be other cognitive and social domains infants can benefit from by attending to information that is familiar to them. For example, infants' familiarity with maternal faces has shown to facilitate 12-month-olds' ability to use maternal facial expressions to guide their behavior in judging whether things are safe or potentially harmful (e.g., Sorce, Emde, Campos, & Klinnert, 1985). Similarly, future research in other domains will provide insights regarding the potential role of familiarity in various types of learning that take place throughout infancy.

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Figure 1. An example of face set stimuli (e.g., Caucasian-happy) presented with superimposed areas of interest (AOIs) within which infant eye movements were recorded.

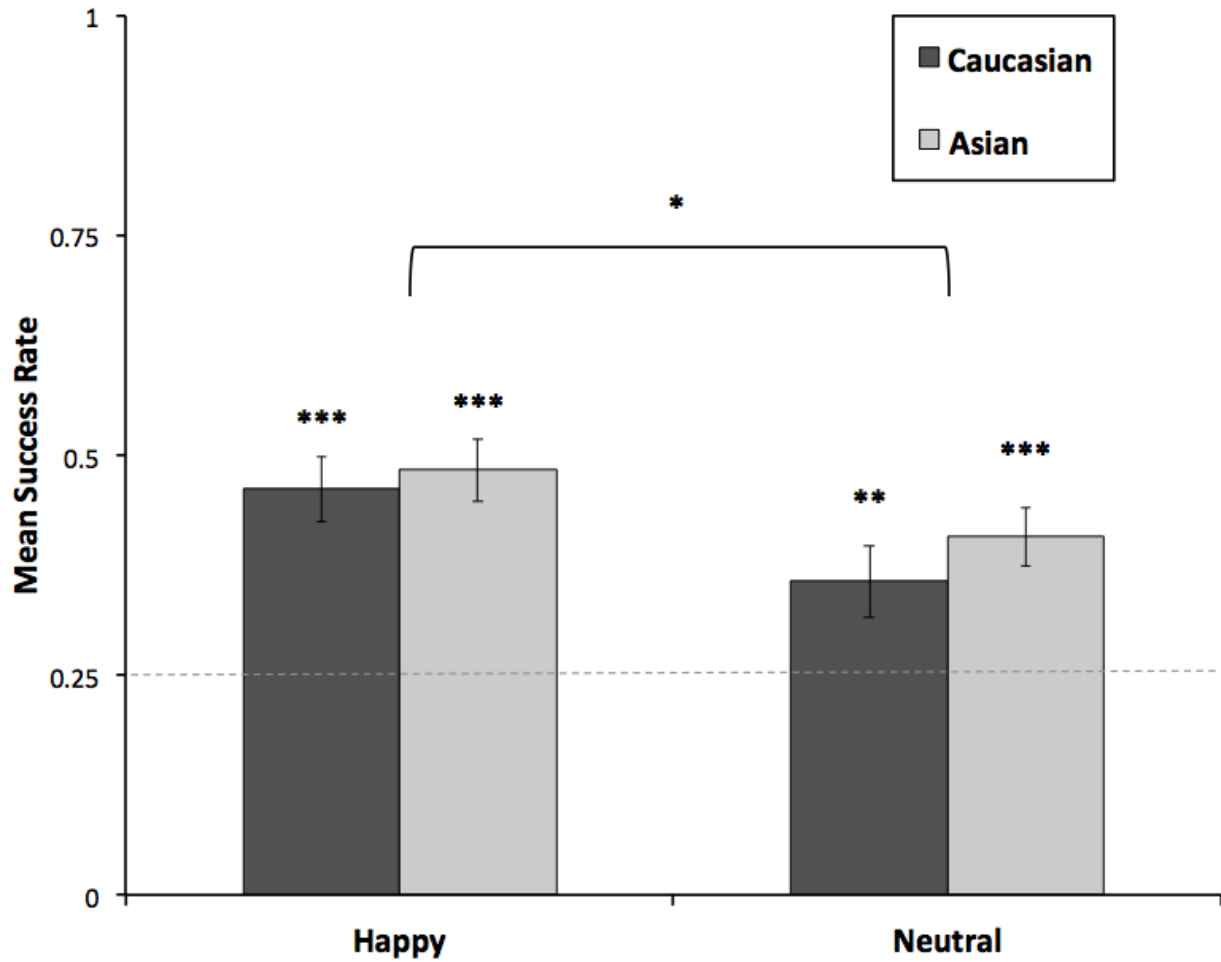


Figure 2. Results showing the mean success rate for each of the four face categories. Success rate is computed by the proportion of the number of successful trials, in which target faces were found within four seconds, out of the total number of trials presented. Results also show how well infants found the target faces compared to chance level (.25) in four face categories. Error bars = *SEM*.

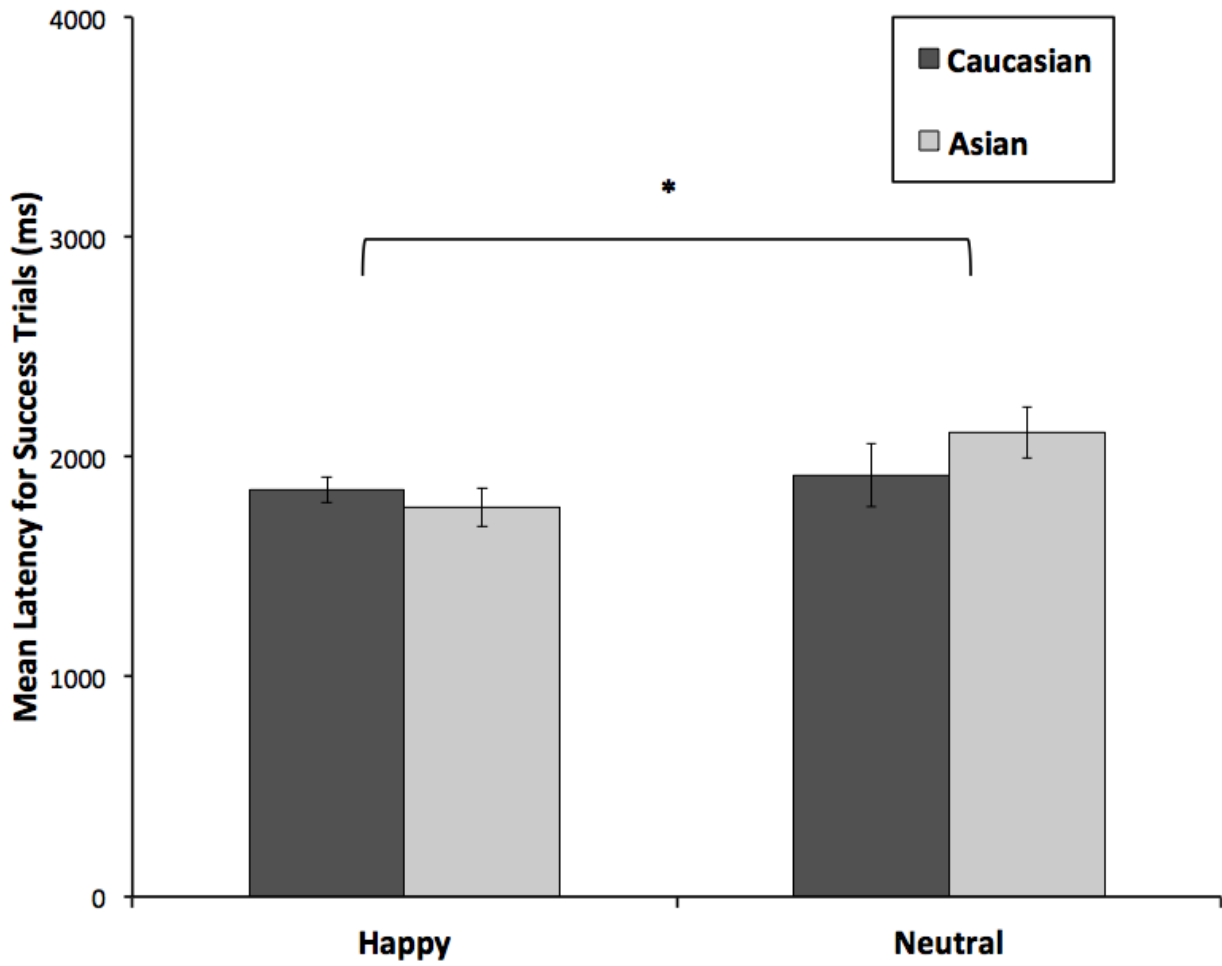


Figure 3. Results displaying the average time taken to find target faces (i.e., latency) in successful trials for each of the four face categories. Error bars = *SEM*.

General Discussion

In a series of four studies, I examined the development of infants' response to happiness and infant-directedness across modalities, found the key property of infant-directed face infants are attracted to, and investigated the effect of happy faces on the other-race effect in infants.

In Study 1, I found infants' visual preference for dynamic presentations of happy faces over sad faces in both 5- and 8-month-olds. However, only the 8-month-olds showed some signs of intermodal emotion matching, suggesting the difficulty of intermodal matching solely based on emotional expressions. Similarly in Study 2, I demonstrated infants' visual preference for dynamic presentations of infant-directed (ID) faces over adult-directed (AD) faces in both 3- and 5-month-olds. However, only the 5-month-olds were able to change their looking behavior in accordance with the type of speech they heard. Taken together, these studies showed that infants overall preference for familiar faces (i.e., happy faces, ID faces) when paired with unfamiliar faces (i.e., sad faces, AD faces). In addition, older infants are more experienced with these familiar categories (i.e., happiness, infant-directedness), and their experiences with the familiar stimuli also seemed to facilitate, albeit indirectly, the way they process the unfamiliar face categories, reflected by the intermodal matching response which was found only in older groups of infants in both studies.

Furthermore, in both studies, many infants seemed to have trouble with matching the face and voice according to the exclusive cues provided in the experiments (i.e., emotion in Study 1, directedness in Study 2), probably because temporal synchrony between faces and voices was disrupted. Eliminating temporal synchrony between the audio and visual stimuli was necessary to prevent infants from detecting the audiovisual relation based on synchrony, a behavior that can be observed even in newborns (e.g., Lewkowicz, Leo, & Simion, 2010). In doing so,

however, the face and voice stimuli were made to appear less familiar to infants because infants are much more used to processing faces and voices in synchrony. Thus, this decrease in infants' familiarity with the stimuli in turn could have hindered infants from doing an effective intermodal matching.

In Study 3, I found that infants' preference for ID faces, as demonstrated in Study 2, is more adequately explained by infants' affinity for happy faces rather than their preference for infant-directedness. Such finding is intelligible because ID faces, similar to ID speech, are primary means to communicate emotional expressions to infants, and because infants are exposed to happiness much more frequently than other emotions. Thus, when both ID and AD faces display the equivalent level of happiness, infants do not prefer ID faces despite that ID faces are different from AD faces in other properties such as tempo and repetitions, suggesting that the familiar emotion conveyed in both faces is what infants are mainly attracted to. Moreover, the finding regarding infants' preference for *happy* AD faces over *sad* ID faces confirms infants' heightened response to happiness expressed in faces. In other words, infants preferred AD faces over ID faces in this particular comparison because infants are more familiar with happy faces than sad faces regardless of whom the faces are directed to.

The findings of Study 4 provide evidence that infants can actually benefit from their familiarity with happy faces. When testing 9-month-olds' ability to discriminate own- and other-race faces using the visual search paradigm, I found that infants showed faster and more accurate discriminatory responses when viewing happy faces than when viewing neutral faces, while they were equally good at distinguishing multiple examples of own- and other-race faces. Contrary to the previous findings (Bar-Haim et al., 2006; Kelly et al., 2007; 2009), I did not replicate the other-race effect in 9-month-old Caucasian infants, which could be explained partly by the

differences in the paradigm. However, the fact that infants still showed reliably different discriminatory responses to familiar (i.e., happy) and unfamiliar (i.e., neutral) faces suggest that infants are able to use familiar emotion to discriminate faces.

Recent evidence suggests that infants' exposure to familiar face categories, such as female faces and own-race faces, leads to infants' ability to form categories based on face race. For examples, Anzures and colleagues (2010) found that 9-month-old Caucasian infants, but not 6-month-olds, are able to form discrete categories of Caucasian faces and Asian faces. Moreover, 9-month-olds' categories of own-race and other-race faces were qualitatively different such that while 9-month-old Caucasian infants formed a robust category of Caucasian faces (i.e., infants were able to further discriminate multiple Caucasian faces at the individual level), their categorization of Asian faces was much weaker (i.e., infants could not discriminate between other-race faces). Similarly, infants' differential exposure to happy faces and faces of other emotions leads to a similar pattern of categorization. For example, infants as young as 5 months show early signs of forming categories of happy facial expressions, by showing similar responses to happy faces varying in intensity and across individuals (Bornstein & Arterberry, 2003). Surprisingly, however, there is not compelling evidence supporting infants' superior ability to categorize familiar emotions compared to unfamiliar emotions (see Quinn et al., 2011 for a review), suggesting further research is much needed on this topic.

Another area of research useful to complete our understanding of how infants' familiarity with happiness shapes their perceptual system is the investigation of special populations of infants who are not readily exposed to happiness in their social environment. It has been demonstrated that, compared to other infants, infants and children raised by primary caregivers with clinical depression are often exposed to much more expressions of sadness, anger, and

neutral (for summary, see Dawson et al., 2003). As a result, these infants tend to perceive sad expressions as more familiar than happy expressions (Hernandez-Reif, Field, Diego, Vera, & Pickens, 2006). Thus, it is unclear if these infants can utilize happiness to guide their perception as other infants would. Furthermore, it is also unknown whether these infants' familiarity with sad expressions can benefit or hurt their ability to discriminate own- and other-race faces.

In sum, happiness is ubiquitous in infants' social environment, and it is clear that infants are not only familiar with happiness but also show heightened sensitivity to stimuli containing happiness. Furthermore, how infants might use this familiar emotion to guide and shape their perceptual system remains to be seen. Future studies are warranted to examine if infants' affinity for happiness will lead to potential advantages in other domains of the social and cognitive development.

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