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7- and 12-Month-Olds' Intermodal Recognition of Affect: 7-Month-Olds are "Smarter" than 12-Month-Olds

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ABSTRACT

7- and 12-Month-Olds' Intermodal Recognition of Affect:
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Research has shown that by 7-months of age infants demonstrate recognition of emotion by successfully matching faces and voices based on affect in an intermodal matching procedure. It is often assumed that once an ability is present the development of that ability has "ceased." Therefore, no research has examined if and how the ability to match faces and voices based on affect develops after the first 7-months. This study examined how the ability to match faces and voices based on affect changes from 7- to 12-months. Looking at infant's proportion of total looking time (PTLT) results showed that, consistent with previous research, 7-month-old infants looked significantly longer at the affectively congruent facial expression. However, 12-month-olds showed no matching of faces and voices. Further analyses showed that 7-month-olds also increased their looking to facial expressions while being presented with the affectively congruent vocal expression. Once again, 12-month-olds failed to show significant matching. That 7-month-olds were able to demonstrate matching while 12-month-olds failed to do so is possibly a result of 12-month-olds attending to other information. More research is needed to better understand how infants' recognition of affect and overall perceptual abilities change as they develop.

Keywords: infant affect recognition, intermodal matching, intersensory redundancy hypothesis

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7- and 12-Month-Olds' Intermodal Recognition of Affect: 7-Month-Olds are "Smarter" than 12-Month-Olds

Communication is perhaps one of the most important skills humans develop. This is evidenced by the fact that human infants are communicative from birth (Gibson & Pick, 2000). One of the first communicative skills that infants develop is the ability to discriminate between and recognize expressions of emotion. This skill is important because it is a key component of social referencing – the ability to use a parent's or adult's affective response to a situation to influence their own response to the situation (Feinman, 1982).

Over the past 30 years, a substantial body of research has been generated in terms of understanding when and how infants learn to recognize and discriminate various expressions of affect (see Walker-Andrews, 1997 for a review). In general, this research concludes that the ability to *discriminate* various expressions of affect is present by 5-months of age but, in some contexts, it can be evidenced in infants as young as 10 weeks (Haviland & Lelwica, 1987). Research also shows that infants can *recognize* affect in both vocal and visual expressions about 2-months later, i.e., between 5- and 7-months of age (Walker-Andrews, 1986). While much is known regarding the emergence of infants' ability to discriminate and recognize various expressions of affect to date there is no literature examining how these abilities change, or continue to develop, after they have emerged. In addition, we assume the ability to discriminate and recognize emotion does not "go away" but there is no systematic evidence as to 1) whether and 2) how infants' discrimination and recognition of affect changes *after it has emerged*. The purpose, therefore, of this project is to examine whether and how infants' recognition of affective expressions changes over the course of development.

Infants' Discrimination of Affect

Discrimination of affect is the ability to perceive a difference in expressions of emotion. It is important to note that affect discrimination and affect recognition do not refer to the same ability or capacity. Discrimination, in this context, and others, is defined as noticing that "X" and "Y" are different. Discrimination does not imply that the infant, or some other organism, comprehends *why or how* something is different, only that the two stimuli *are* different. Recognition, in this context, and others, is defined as noticing that "X" and "Y" are related. For example, it is noticing that happiness communicated in vocal expression is similar to, or related to, happiness communicated in a facial expression. While these two "abilities" are related within the larger context of perceiving emotion, they are distinct where affect discrimination tends to emerge 1-2 months prior to infants' recognition of affect (Walker-Andrews, 1997).

The most common procedure for studying infants' discrimination of affective expression involves the use of what has been termed an infant-controlled habituation/dishabituation procedure. In this procedure an infant is presented with a stimulus until he becomes bored or habituated to that stimulus. Once an infant successfully habituates to the stimulus a novel stimulus is then presented to the infant and the infant's looking time to the new event is recorded. If the infant attends to the novel stimulus for longer than it attended to the original stimulus at the point of habituation it is concluded that the infant was able to discriminate between the two stimuli.

Early studies examining infants' discrimination of affect focused on infants' ability to discriminate affect in faces (Barrera & Maurer, 1981; LaBarbera, Izard, Vietze, & Parisi, 1976; Nelson, Morse, & Leavitt, 1979; Young-Browne, Rosenfield, & Harowitz, 1977). While these studies differed in the specifics of their procedures and results generally these studies revealed that by 5-months infants could discriminate a smiling from a non-smiling facial expression

(Caron, Caron, & Myers, 1982). However, the results of some experiments were limited by infants only showing discrimination when habituated to a smiling or happy expression and not when habituated to a non-smiling facial expression (Ludemann & Nelson, 1988). For example, Caron et al. (1982) were able to show that 5½-month-old infants could discriminate a surprise expression from happy expression but only if the infants were habituated to the happy expression and not when habituated to the surprise expression. Likewise, additional studies have found that 7-month-old infants could discriminate facial expressions of happy from fear only if they were habituated to the happy expression (Ludemann & Nelson, 1988; Nelson et al., 1979).

Attempts to address problems associated with the order of habituation, as well as other issues, resulted in considerable variation in how experiments examining infants' discrimination of affect in faces were conducted (Ludemann & Nelson, 1988). Some studies used static images of a stranger expressing emotion (LaBarbera et al., 1976; Nelson et al., 1979; Young-Browne et al., 1977) while others used static images of the infants' mother posing emotional expressions (Barrera & Maurer, 1981). Studies also varied in the use of a single face (Browne et al., 1977; LaBarbera et al., 1976) or multiple faces during habituation (Caron et al., 1982; Nelson et al., 1979). Other studies have considered and compared the use of static and dynamic faces. For example, Caron, Caron, and MacLean, (1988) suggest dynamic (moving) images of affective facial expressions more accurately convey the adult's affective expression and may subsequently promote infants' discrimination of affect. Using dynamic facial expressions, Flom and Bahrick (2007) were able to show that at 7 months infants are indeed able to discriminate happy, angry, and sad facial expressions. Despite these variations, experiments tended to produce roughly similar results.

While one's facial expression is one way that an affective expression can be communicated, it is not the only way in which human beings communicate affect or emotion. The human voice, for instance, also communicates or otherwise conveys expressions of emotion. Research examining infants' discrimination of affect in the context of human voices reveals that infants' ability to discriminate affect in voices as well as faces tends to emerge around 5-months of age (Walker-Andrews & Grolnick, 1983; Walker-Andrews & Lennon, 1991). Unfortunately, the literature on infant discrimination of affect in voices is limited, relative to discrimination of affect using faces.

While little is known regarding infants' discrimination of affect in voices alone, much has been done assessing whether and when infants are able to discriminate affect in the context of faces *and* voices. At the surface it is perhaps intuitive that a majority of experiments examining infants' discrimination of affect have used faces paired with voices compared to voices alone or faces alone as infants often participate in communicative exchanges where the adult's face and voice are available. It is perhaps somewhat more infrequently the case that infants only see or only hear what an adult is communicating.

Recently, Flom and Bahrick (2007), examining infants' discrimination of affect in faces-voices, found that somewhat younger infants (4-month-olds) are able to discriminate affect when conveyed in a face-voice compared to a face alone (7-month-olds) or voice alone (5-months). Other studies have demonstrated that presenting 5-month-old infants with matching expressions of affect in both faces and voices greatly facilitated their ability to discriminate expressions of affect (Walker-Andrews & Lennon, 1991). Likewise Haviland and Lelwica (1987) suggested that using both faces and voices in affect presentation not only simplifies discrimination of affect (joy, anger, and sadness) for older infants but also demonstrates discrimination of affect in

infants as young as 10 weeks. Haviland and Lelwica's (1987) result is important because it is one of the few experiments to date to show discrimination prior to 4-5 months of age. It is important to recognize, however, that Haviland and Lelwica (1987) had the infants' mothers present or convey the affect "live" rather than using an unfamiliar adult via videotape/flim. The use of a live, familiar face undoubtedly aided the infants' ability to discriminate. However, Haviland and Lelwica's (1987) results demonstrate that at a very early age, infants are learning to discriminate affect using a combination of facial and vocal cues.

Following up on Haviland and Lelwica's (1987) study, Caron et al. (1988) examined how combining voices with dynamic faces influenced infants' ability to discriminate affect. Their results suggest that 1) infants can discriminate affect in dynamic faces and voices together at 5 months and 2) infants cannot discriminate affect in dynamic faces alone until 7 months. In a synthesis of the current literature on infant perception of affect, Walker-Andrews (1997) proposed that this sequence occurs because infants first learn to discriminate affect by combining multiple modes of information (primarily facial and vocal information). Only after infants learn to discriminate affect in multimodal events do they learn to discriminate affect in faces and voices alone. Flom and Bahrick (2007) examined the above hypothesis and found that infants first learn to discriminate affect in facial and vocal expressions together (4 months) followed by the ability to discriminate affect in voices alone (5 months) and faces alone (7 months). Thus, it seems the developmental pattern of affect discrimination in infants is discrimination first in voices and faces followed by discrimination in voices alone and then discrimination of faces alone.

As noted previously, infant discrimination has been largely studied using the infant-controlled habituation procedure. One possible weakness of the infant-controlled habituation

procedure is that infants may attend longer to a novel stimulus simply because of changes in specific aspects of the stimulus (such as brow or lip movement) and not because of a perceived change in facial expression (Ludemann & Nelson, 1988; Nelson & Dolgin, 1985). Studies sometimes vary in their technique in an attempt to control for this possibility by using multiple models' faces (Caron et al., 1982; Nelson & Dolgin, 1985; Nelson et al., 1979). In general, these studies, along with others, suggest that infants generalize discrimination across faces and that habituation is a valid technique for studying discrimination in infants.

Infants' Recognition of Affect

As mentioned earlier, discrimination and recognition in the context of "infants' perception of emotion" are not synonymous. That is knowing that "X" and "Y" are different is not the same as knowing what "X" is or "Y" is. Recognition is an understanding of what "X" or "Y" represent. It can also be an understanding that "X" and "Y" are related. Within the context of infants' recognition of affect, it is the idea that infants recognize what is common across a visual and auditory representation of a particular emotion.

Infants' recognition of affect is commonly studied using an intermodal matching procedure. In this procedure developed by Spelke (1976), the infant is tested to see if she is able to match, i.e. recognize, one stimulus from one sense modality with another corresponding stimulus from a different sense modality. Typically, the infant is simultaneously presented with two side by side visual stimuli displayed and is accompanied by an auditory stimulus that matches one of the two visual stimuli. Infants are repeatedly presented with the two visual stimuli and a matching auditory stimulus while observers record the infants looking time to each face. If the infant attends longer to the matching face, then it is inferred that the infant recognizes or perceives what is common across the vocal and facial expressions.

The first study to examine infants' recognition of affect was done by Walker (1982). Walker (1982) noted that while much research was identifying when and how infants learned to discriminate affect, very little was being learned about infants' ability to "put meaning into affective expressions." Walker (1982) proposed that infants could detect meaning that was invariant across affective vocal and facial expressions. To test this hypothesis, Walker (1982) conducted a series of experiments using the intermodal matching technique. Walker (1982) investigated whether 7-month-olds could detect meaning (i.e., recognize what was invariant across affective vocal and facial expressions of happy, neutral, and sad). The results showed that 7-month-old infants could match an affective vocal expression with an accompanying affective facial expression. In a second experiment Walker (1982) was able to replicate the results of the first experiment using 5-month-old infants.

Walker (1982) recognized multiple alternative explanations as to why the infants in her study were able to show intermodal matching. One explanation was that infants may be matching the faces with voices based on the *synchrony* between facial movements and vocal expression. Another possible explanation was that infants might be matching faces and voices based on similarities in the *intensities* of the affective expressions. In essence, an infant might match a happy voice that has a large range of pitch and loudness with an animated happy face and not a less animated sad face. The explanation that Walker (1982) felt was most plausible was that infants were able to match based on a common meaning shared by the matching face and voice.

In a third and fourth experiment, Walker (1982) tested these alternative explanations. In the third experiment, Walker (1982) adjusted the vocal expression by 5 seconds where it was no longer in synchrony with the accompanying facial expression. With the matching facial and vocal expressions asynchronous, 7-month-old infants were still able to match the affective facial

and vocal expressions. In the fourth experiment, Walker (1982) paired happy and angry facial and vocal expressions because happy and angry expressions are similar in their levels of intensity. Walker (1982) also inverted the displays for some the infants so that the facial expressions were upside down to see if infants could match based on synchronous information. In this experiment, 7-month-old infants successfully matched happy and angry expressions but not when the events were inverted.

The ability to match asynchronous facial and vocal expressions along with infants' inability to match inverted facial expressions suggests that infants use more than tempered synchrony to match affective facial expressions (Walker, 1982). Walker (1982) also interpreted infants' ability to match happy and angry expressions to mean that infants do not use expression intensity to match affective facial and vocal expressions. These experiments were the first to show that by 7 months, infants are able to detect meaning that is shared by facial and vocal expressions of affect (Walker, 1982).

Walker's (1982) study was groundbreaking in that it was the first study to assess infants' ability to perceive similar affective information in facial *and* vocal expressions. Subsequent studies explored what information infants were using to recognize affect in facial and vocal expressions. Walker-Andrews (1986) examined how the presence or absence of the mouth influenced 5- and 7-month-old infants' ability to match affective expressions in faces and voices. To test this, Walker-Andrews (1986) covered the mouth while displaying facial and vocal affective expressions. Walker-Andrews (1986) showed that 7- but not 5-month-old infants were able to match affective expressions. Walker-Andrews (1986) suggested that 7-month-old infants are able to match affective expressions using only information from the upper part of the face but that 5-month-old infants require more information in order to match affective expressions.

Walker-Andrews (1986) suggested that 5-month-old infants need to see a mouth in order to match affective expressions which might indicate that 5-month-old infants rely more on synchronous information in affect recognition than do 7-month-old infants.

Soken and Pick (1992) were interested in how motion information facilitated infant affect recognition. To investigate infants' use of motion information in affect recognition, Soken and Pick (1992) used a procedure developed by Johansson (1973) involving point light displays. In a point light display, an actress is covered in black makeup followed by white dots and then recorded. The recording shows only the white dots which reflect facial motion. They then tested 7-month-old infants to see if they could match affective voices with the appropriate point light display and found they were able to do so. Soken and Pick (1992) suggest that the infants' ability to match affective expressions in the point light condition demonstrates that 7-month-old infants can recognize affect on motion information alone. Soken and Pick (1992) repeated the same procedure, except this time they played the soundtracks 5 seconds out of synchrony. Once again, the infants were able to match affective expressions. The study showed that 7-month-old infants use synchronous information and that they also use motion information to recognize affect (Soken & Pick, 1992).

More recently, Walker-Andrews (1998) investigated how familiarity influenced infants' ability to recognize affect. Walker-Andrews (1998) tested 3.5-month-old infants' ability to match affective expressions using either the infant's mother's face and voice or a stranger's face and voice. They found that 3.5-month-old infants could match affective expressions but only if the expressions were presented by their mothers (Walker-Andrews, 1998). Kahana-Kalman and Walker-Andrews (2001) replicated those results and also found that, even when the information was asynchronous, infants were still able to match if their mothers presented the expressions. In

addition, blind coders coded videotape recordings of the infants' responses to the displays. Infants responded more positively to presentations of happy faces and voices, especially if the faces and voices belonged to the infants' mothers. Infants' reactions demonstrate that infants not only recognize certain affect expressions but are able to put some meaning behind affective expressions (Kahana-Kalman & Walker-Andrews, 2001).

More recent research has examined how infants' ability to recognize affect extends beyond human beings (Flom, Whipple, & Hyde, 2009). Flom et al. (2009) studied infants' ability to match canine aggressive and nonaggressive vocalizations with the appropriate canine facial expressions. Flom et al. (2009) showed that infants as young as 6 months are able to perceive relationships between canine vocalizations and facial expressions. Importantly, Flom et al. (2009) found that as infants got older they seemed to show a decreased ability to match canine expressions. Infants' decreased ability to show recognition across species has been explained as evidence of perceptual narrowing: a process through which infants learn to recognize only information that is relevant to humans (Lewkowicz & Ghazanfar, 2006). Thus, young infants have the ability to perceive intersensory information across species but as infants get older, they seem to lose that ability (Lewkowicz & Ghazanfar, 2006). Flom et al. (2009) argued, however, that infants do not lose the ability to perceive intersensory information across species but that the ability changes as infants get older. Specifically, Flom et al. (2009) showed that older infants showed cross-species intersensory matching of affect not by how much time they attended to the matching stimulus *but by the direction of the infants' first look.* That is, older infants did not attend longer to the matching canine face, however, the direction older, but not younger, infants first looked was toward the matching canine face.

Over the first year of life, humans are already developing the ability to recognize affect (Walker-Andrews, 1997). The patterns of development suggest that infants begin recognizing affect by recognizing affective information that is invariant across multimodal presentations (Walker-Andrews, 1997). As infants get older, they begin to differentiate multiple modes of affect expression and recognize them as such.

Although we now know that by 7 months infants can demonstrate affect recognition, no one has actually attempted to study how infants' ability to recognize affect develops as they get older. It is often assumed that once an ability has emerged that development has "ceased" (Lewkowicz & Ghazanfar, 2006). However, as demonstrated by Flom et al. (2009) development of recognition does not necessarily "cease" but we may have to adjust the procedures we use measure it. The purpose of this study was to examine infants' ability to match faces and voices (using affective expressions – happiness, sadness, etc.) and more importantly examine how this ability changes from the age of 7 months (when the ability to match faces and voices based on affect first begins) to 12 months. It was predicted that 7- but not 12-month-olds would show reliable matching when assessed using infants' proportion of looking time directed to the sound specified event while 12- but not 7-month-olds would show matching when assessed using infants' direction of first look to the sound specified event

Methods

Participants

Sixteen 7-month-olds (seven females) ranging in age from 204 to 228 days (mean age 7 months and 1 day) and sixteen 12-month-olds (six females) ranging in age from 360 to 372 days (mean age 12 months and 1 day) participated. To ensure infants were full term, ten infants who were born more than two weeks before their due date were excluded from analyses. Participants

were identified using local birth records. Parents of the participants were initially contacted by telephone. During the initial telephone contact, the purpose of the study was explained to the parent who was asked if they were willing to have their son or daughter participate in this study.

Exclusion Criteria

Infants were required to complete all eight trials. It is also important that infants notice that there were two video events side by side thus an attention criterion required that infants look at least 5% of the time to the least preferred display (e.g., Kahana-Kalman & Walker-Andrews, 2001). Thirteen additional infants who failed to meet this criterion on any of the eight trials were excluded from the analyses and their data replaced by other infants. An additional six infants became fussy, upset, or were otherwise unable to complete the experiment and their data was excluded from the analyses and replaced by other infants. Finally, seven additional infants were not included in the analyses due to equipment failure or experimenter error and their data was replaced by other infants.

Stimuli

The events consisted of photographs of two actors conveying sadness and happiness. The photographs used in this experiment were taken from the videotaped events used in Flom & Bahrick (2007). The auditory events in the current experiment were also taken from Flom and Bahrick (2007) and consisted of the actors saying the phrase “Hi baby, look at you. You’re such a beautiful baby. Your mommy and daddy must be so proud to have a beautiful baby like you” in a sad and happy voice. The auditory events, paired with the photographs, were looped creating one 10-min excerpt and were burned to a DVD.

Apparatus

The photographs of each actor were obtained with a Sony digital camera (DSR 250; Sony Corp., Tokyo, Japan), and edited with Apple's iPhoto digital editing program (Apple Inc., Cupertino, CA), burned to DVD and presented with two Sony (DVP-NS57P/B) DVD players. The DVD players were connected to two 26-inch (66-cm) color video monitors (LG 26LH20). The audio recordings were presented from a speaker located between the two monitors at approximately 65 decibels as measured from the infant's seat. The photographs were presented to the two monitors via an edit controller connected to the DVD players.

Infants sat facing the video monitors approximately 50 cm away. Two apertures cut into a black foam board surrounding the monitors were used to record the infants' visual fixations. The experimenters (i.e., observers), unaware of the hypotheses of the experiment and unable to view the visual events, pressed a button while the infant was fixated on the event (i.e., a face) and the button was released when the infant looked away. The button boxes were connected to a computer programmed to record visual fixations online. Another experimenter (who controlled the presentation of the video displays) received a computer signal through a small earphone that indicated when the trial should end. The observations (i.e., pressing and releasing of the button on the button box) of the first experimenter (i.e., primary observer) were recorded onto a computer and used for the analyses.

Counterbalancing

Half of the infants at each age saw the happy expression on the left first, and half saw the sad expression on the left first. The lateral positions of the happy expression and the sad expression were switched after the fourth trial. Finally, half of the infants at each age heard sad on the first trial and half heard happy on the first trial.

Procedure

Infants participated in an intermodal-matching procedure (Spelke, 1976). In this, and other experiments using this procedure, infants are procedurally "asked" whether they detect the perceptual correspondence between information presented across two different sensory systems. Traditionally, and in the current experiment, infants view two visual events or images while hearing an auditory event that corresponds to one of the visual events (see Kellman & Arterberry, 1998, for a review of this procedure). In many experiments using this procedure infants typically look proportionately longer to the sound-matched or congruent event (e.g., Bahrick, Hernandez-Reif, & Flom, 2005; Lewkowicz & Ghanzafar, 2006; Walker, 1982; Walker-Andrews, 1986), although in some circumstances infants' look proportionately longer to the mismatched or incongruent event (e.g., Bahrick & Watson, 1985; Rochat & Morgan, 1995; Schmuckler & Fairhall, 2001). In the current experiment, based on other studies of affect recognition, it was predicted that 7-month-old infants would look longer to the sound specified or matching event (see Walker, 1982; Walker-Andrews, 1986).

During the experiment, each infant received eight 20s trials. On all eight trials, infants were presented simultaneously with a happy and sad facial expression. On four trials, the infant heard a happy vocal expression, and on four trials, the infant heard a sad vocal expression. The eight trials were divided up into two blocks with four trials in each block. Each block was further divided into two sub-blocks (i.e., sets) with two trials in each set. For the first set of two trials infants were presented with the same affective vocal expression while the second set of two trials consisted of the other affective vocal expression. So if the infant was presented with (i.e., heard) a happy voice on trials one and two it was presented with a sad voice on trials three and four. The second set of four trials followed the same pattern as the first except that the lateral position

of the happy and sad facial expressions was switched. Static facial expressions were used to avoid the possibility of infants matching based on temporal synchrony between the matching facial and vocal expressions.

For 25% of the total participants observations of a second observer were recorded onto the computer and were used in the computation of interobserver reliability. Interobserver reliability was calculated by finding the Pearson r correlation of the experimenters' observations. For experiment one, the average correlation was .91 (*SD* = .14).

Results

Proportion of Total Looking Time

The primary dependent variable was the proportion of total looking time (PTLT) that infants looked toward the sound/voice-specified (i.e., matching) facial expression. Proportions were derived for each trial separately by dividing the time spent looking to the voice-specified display (i.e., congruent display) by the time spent looking at both displays (i.e., congruent + incongruent displays). An overall PTLT was derived by averaging across all trials (four happy and four sad) and averaging over all infants at each age. In order to determine whether infants demonstrated intermodal matching of the faces-voices and using a one-sample t-test the mean PTLT's were compared against the chance value of .50 at each age (assuming equivalent looking to the two faces).

Seven-month-olds showed differential looking to the photographs. For both the happy and sad trials combined, 7-month-olds' proportion of total looking time (PTLT) to the matching face (M = .53, SD = .05) reached significance, $t(15) = 2.39$, $p < .05$, and is in concordance with previous studies showing intermodal matching of faces and voices based on affect using proportion of total looking time (Walker, 1982; Walker-Andrews, 1986). Twelve-month-olds, in contrast, did not show reliable evidence of matching. Specifically, 12-month-olds overall

proportion of total looking time (PTLT) to the matching face (M = .51, SD = .05) failed to reach significance. Thus 7-month-olds, but not 12-month-olds, showed reliable intermodal matching of affective faces and voices using PTLT.

Matching of Happy Faces and Voices

Given that 7-month-olds showed significant overall matching of happy/sad faces and voices it was assessed whether 7-month-olds showed reliable matching to the happy face/voice and the sad face/voice pairing independently. Results revealed 7-month-olds showed reliable matching of happy faces and voices (M = .58, SD = .09, $t(15) = 3.59$, $p < .01$) but not sad faces and voices. Thus it seems likely that the significant overall matching of the 7-month-olds is a result of their matching the happy face and voice. Interestingly, however, while the 12-month-olds' overall matching failed to reach significance, 12-month-olds did show reliable matching of the happy face and voice (M = .54, SD = .07, $t(15) = 2.22$, $p < .05$). Finally 7-month-olds (M = *.55, SD = .06, t(15) =3.2, p <.01)* but not 12-month-olds (*M = 51, SD = .08, t(15) =.24 p >.1)* showed a reliable preference for the happy face across all trials.

The fact that 7- and 12-month-olds showed reliable matching of happy faces and voices, but not sad faces and voices, and 7-month-olds also showed an overall preference for the happy face is consistent with prior work. For example, Soken and Pick (1992) and Kahan-Kalman and Walker-Andrews (2001) demonstrate that infants prefer to look at happy facial expressions regardless of the affective congruency of the vocal expression presented and were able to match happy faces and happy voices with limited evidence of matching sad faces and voices.

Increased Looking to Matching Expressions

While many studies examining infants' intermodal perception of affect use infants' proportion of total looking time (PTLT) to the congruent face (as reported above) as the primary

dependent variable, an alternate, and potentially more reliable, way to explore infants' intermodal matching is to examine whether infants' look longer to a sad face when paired with a sad voice than when paired with a happy voice. The advantage of this approach is that it controls for infants' overall preferences for a particular face/affect. For instance, if infants show an overall preference for a *happy face* the probability of infants' looking greater than 50% (i.e., chance) to the *sad face* when presented with a *sad voice* is minimal given the initial preference for the happy face. Using a paired samples t-test, 7-month-olds look longer (M = .06, SD = .09) to a happy face when hearing a happy voice than when hearing a sad voice, $t(15) = 2.4$, $p < .05$. This result demonstrates that while 7-month-olds show an overall preference for a happy face compared to a sad face, they look proportionately longer to the happy face when paired with happy voice compared to a sad voice. Likewise 7-month-olds also look longer to a sad face when paired with a sad voice (M = .05, SD = .09) than when paired with a happy voice, $t(15) = 2.34$, $p<.05$. Thus by taking into account 7-month-olds' overall preference for happy, compared to sad faces, the results revealed that 7-month-olds increase their looking to a sad face and a happy when they hear the affectively congruent voice. The results of the 12-month-olds, however, failed to reach significance for either the happy or sad face (both p's >.1) with this analytic procedure.

Matching Within Blocks

The analyses thus far indicate that 7-month-olds show reliable evidence of matching affectively congruent faces and voices and some evidence, using proportion of total looking time (PTLT), that 12-month-olds look proportionately longer at a happy face when they hear a happy voice. One possibility, however, is that 12-month-olds show reliable matching on the earlier trials but not later trials as they may become bored with the task. However, the total amount of

looking (to both matching and mismatching faces) across all trials did not reliably differ between the 7- and 12-month-olds (p >.10). Similarly, both 7- and 12-month-olds' looking behavior did not significantly decrease from the first to the last trial (p >.10). Thus it seems unlikely that 12-month-olds became unduly fatigued during the Experiment. While infants at both ages did not appear to become fatigued as the experiment progressed, it is still possible that 12-month-olds showed matching on the earlier trials but not on the latter trials thus 7-and 12-month-olds' looking to the matching/congruent face on earlier trials was compared to later trials. The results of this analysis at both ages failed to reach significance (p >.10 for both ages). Thus both 7- and 12-month-olds' looking to the matching face did not reliably differ between the first-half and second-half of the Experiment. However, because the counterbalancing in this Experiment caused a change after every set of two trials, differences within trial blocks were also examined. Specifically, we examined 7- and 12-month-olds' looking to the congruent face on the odd trials 1, 3, 5, and 7 (i.e. the first of each set of trials) separate from the even trials (i.e., the second of each set). Results show that 7-month-olds' matching (M = .50, SD = .05) on the first trial of each block failed to reach significance. However, when trials 2, 4, 6, and 8 (i.e. the second of each set of trials) were analyzed, 7-month-old infants' matching PTLT (M = .55, SD = .06) reached significance, $t(15) = 3.58$, $p < .05$. This suggests that 7-month-old infants are able to demonstrate matching of affect in facial and vocal expressions but that they require sufficient time (i.e., an additional trial) to do so. The results of the 12-month-olds failed to reach significance for either the odd (i.e., first trial of each set) or the even trials (i.e., the second trial of each set, both p's >.10).

Finally, infants' first looks toward the visual stimuli were examined but contrary to predictions neither 7- nor 12-month-old infants' first looks toward the matching facial expression reached significance.

General Discussion

The results of this experiment are mixed. Fortunately, results of the 7-month-olds are consistent with previous work examining the development of infants' intermodal matching of faces and voices on the basis of shared or communicated affect. Specifically, 7-month-olds look proportionately longer to the voice matched face compared to the voice mismatched face. While 7-month-olds also showed an overall preference for the happy face compared to the sad face, they nonetheless increased their looking to a sad face when they heard a sad voice and they increased their looking to a happy face when they heard a happy voice. The results of the 7-month-olds also demonstrate that matching occurred during the second trial of each set/block and not during the first trial of each set/block. The fact that this study was able to replicate the results of others (e.g., Walker, 1982; Walker-Andrews, 1986, 1988) is important as it demonstrates that the procedure used in this experiment is sufficiently consistent with prior studies and that 12-month-olds lack of intermodal matching is probably not due to how this experiment was set up. Still, the results of the 12-month-olds are perplexing as they exhibited limited evidence of matching happy faces and voices when using the proportion of total looking time (PTLT) for the happy face/voice and failed to show reliable matching using any other measure.

Why did the 12-month-olds fail to show robust intermodal matching of affect using faces and voices where 7-month-olds show reliable and robust matching? To be certain, there are several possible explanations, some of which will be considered here. The initial reaction to the results of the 12-month-olds might be to suggest that 12-month-olds are unable to match faces and voices based on affect. This response, however, is counterintuitive. The current study, and

prior research, as described above, has repeatedly demonstrated that 7-month-olds show reliable matching. In addition, informally asking adults which face and voice go together leads one to conclude this ability has not diminished in adulthood. Thus, it appears inconsistent to suggest that this ability develops by 7-months of age then goes away by 12-months only to return later.

The fact that this study showed evidence of a "perceptual decline," however, is not novel in and of itself. For example, several studies demonstrate that infants may lose some perceptual abilities as they get older. Perhaps the best-known example of this is a now classic study by Werker and Tees (1984). In this experiment, Werker and Tees (1984) demonstrated that 6-8 month-old English-learning infants were able to discriminate non-native syllables but that by 10-12 months this ability has gone away. Studies have shown similar declines in infants' perceptual abilities with monkey faces and calls (Lewkowicz & Ghazanfar, 2006; Pascalis, de Haan, & Nelson, 2002), human faces not of the infants race (Kelly, Quinn, Slater, Lee, Ge, & Pascalis, 2007), and even rhythmic patterns in music (Hannon & Trehub, 2005). The process of losing perceptual abilities as infants age is known as perceptual narrowing (Lewkowicz & Ghazanfar, 2009). Lewkowicz and Ghazanfar (2009) suggest that infants are born with a broad range of perceptual abilities and that, as infants develop, they increase those perceptual abilities with which they have experience and lose many of the unused abilities. This is supported by the fact that research on perceptual narrowing only demonstrates perceptual narrowing with stimuli to which the infant is not naturally exposed (e.g. non-native languages, monkey faces, faces of other races, and music tempos of other cultures). Previous studies using intermodal matching of faces and voices native to the infant's environment have shown developmental increases in infants' perceptual abilities (Lewkowicz & Ghazanfar, 2009). What is common in studies of perceptual narrowing is the fact that infants' perceptual discrimination (including intermodal

matching) initially begins as quite broad in terms of what infants are able to discriminate as well as recognize, and over time and experience this ability to show discrimination and recognition becomes attuned to the infants' perceptual environment. In other words, unless infants continue to receive exposure or experience with perceptual stimuli, they typically fail to make such perceptual discriminations or show intermodal matching. In the current experiment, however, perceptual narrowing is unlikely because infants of this age (i.e., 12-month-olds) continue to be exposed to faces and voices conveying a variety of affective expressions

A second line of investigation has also shown that infants "lose" a perceptual or cognitive ability by the time they reach toddlerhood. Specifically, Keen (2003) analyzed infants' perception of physical laws that seemed to suggest a decline in these perceptual abilities. For example, discrimination studies looking at infants' perception of solidity showed that 3- to 4-month-olds looked significantly longer when the ball appeared to roll through the solid object. This was taken as evidence that 3- to 4-month-olds have some understanding of physical laws pertaining to objects. However, when later studies tried to demonstrate the same ability in 2-year-olds and 3-year-olds, only the 3-year-olds were able to accomplish the task. Keen (2003) notes that the studies using infants relied on habituation and looking time whereas toddlers were asked to locate (reaching/pointing) where the ball stopped behind a wooden screen with doors. Keen (2003) suggests that this discrepancy in task requirements could explain the 2-year-olds failure to demonstrate an understanding of basic physical laws (for a complete review of the research see Keen, 2003). Moreover, if the toddlers were given a "looking" task rather than a "reaching" task, the performance of the toddlers was comparable to the infants and thus not indicating a loss. In the current study, however, this potential confound was avoided as the exact same procedure was used with both 7- and 12-month-olds and have no empirical reason to

believe that procedural differences account for 12-month-olds lack of intermodal matching of affect.

As noted above, there are no gross differences in the current experiment between the procedure used with the 7- and the 12-month-olds, however, it is possible that some smaller, or more subtle, feature(s) of the experiment can account for the apparent "loss". While most studies of infant affect recognition use the intermodal matching technique developed by Spelke (1976) there is some variability as to the specifics of how the procedure is used. For example, there is considerable variability as to the length of each trial and the number of trials used in the study. It is possible that some of the variations in the number and duration of the trials in this study account for 12-month-olds' apparent inability to match faces and voices based on affect. That is, on the first of each set of trials (i.e., the odd trials) 7-month-olds showed no reliable evidence of matching. However, on the second of each set of trials (i.e., the even trials) -- after the 7-month-olds had already received 20 seconds of exposure to the stimuli -- they were able to demonstrate intermodal matching. Because the processing speeds of a 12-month-old are faster than those of a 7-month-old it is possible that 12-month-olds should show matching on earlier (odd), but not later (even) trials. Results, however, failed to support this possibility. Future research may re-examine this possibility by shortening the length of each trial from 20s to 5-10s per trial.

Another possibility is that the intermodal matching procedure is simply inappropriate for 12-month-old infants. However, 12-month-olds have successfully shown intermodal matching of faces and voices on the basis of gender (Poulin-Dubois, Serbin, Kenyon, & Derbyshire, 1994) and 24-month-olds have shown appropriate preferential looking to gender consistent and inconsistent events (Serbin, Poulin-Dubois, & Eichstedt, 2002). Likewise studies of language development have used both intermodal matching and preferential looking procedures with

infants from 14- to 24-months age (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 2001; Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Hirsh-Pasek & Golinkoff, 1996). However, as no studies using intermodal matching procedures have specifically looked at older infants' recognition of affect it may be that intermodal matching works for some intermodal tasks such as intermodal matching on the basis of a common gender or semantic meaning but not using more "basic" perceptual tasks like affect recognition.

The last possibility to be explored is the possibility that 12-month-olds fail to show intermodal matching of affect because they are not attending to the affective information and are attending to other information. For example, the intersensory redundancy hypothesis originally articulated by Bahrick, Lickliter, & Flom, (2004) predicts and demonstrates that younger infants initially attend to information that is amodal (i.e., information that can be perceived by multiple sense modalities) while older infants are more flexible in terms of their perceptual attention and can thus attend to amodal information as well as modality-specific information (i.e., information that is restricted to a single-sense modality). In early development, infants' attention is captured and directed toward those properties that can be redundantly specified across more than one sense modality, and over the course of development, infants become more flexible in terms of what captures their attention and what information they attend to. For instance, Bahrick and Lickliter (2004) showed that 3-month-old infants were able to discriminate a change in tempo of a hammer tapping during bimodal (audiovisual) but not unimodal (audio or visual) presentations. However, 5- and 8-month-old infants were able to discriminate the same stimuli in bimodal *and* unimodal presentations. Research on infant affect discrimination also supports the intersensory redundancy hypothesis (see Flom & Bahrick, 2007 described within the introduction).

While the current experiment was not designed to study the intersensory redundancy hypothesis, it may help explain why 7- but not 12-month-olds were able to demonstrate intermodal matching. That is, while 7-month-olds are able to attend to unimodal information they will attend to bimodal information if it is present. Older infants (e.g. 12-month-olds), in contrast, may attend to bimodal information briefly (or perhaps not at all) and then attend to unimodal information. If this hypothesis is true, then one would predict that 12-month-olds would initially, and very quickly, detect the amodal correspondence of the common affect across the faces and voices, and then would attend to the modality specific properties of the event such as the appearance of the face and various acoustic properties of the voice

To be clear the above explanations are ad-hoc. The most conservative approach is that it is unclear exactly why 12-month-olds were unable to match facial and vocal affective expressions. Still, the results of the 7- and 12-month-olds demonstrate that researchers must continue to investigate how development proceeds *after* a particular behavior or skill emerges. These results suggest that behaviors change as they emerge and continue to change after they have emerged. Future research examining the emergence, and continued development of affect recognition in infants will not only further our understanding of affect recognition in infancy but will also further our understanding of development broadly construed.

References

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

Bahrick, L. E., & Lickliter, R. (2004). Infants' perception of rhythm and tempo in unimodal and multimodal stimulation: A developmental test of the intersensory redundancy hypothesis. *Cognitive, Affective & Behavioral Neuroscience, 4*(2), 137-147. doi:10.3758/CABN.4.2.137

Bahrick, L. E., Lickliter, R., & Flom, R. (2004). Intersensory redundancy guides the development of selective attention, perception, and cognition in infancy. *Current Directions in Psychological Science, 13*(3), 99-102. doi:10.1111/j.0963-7214.2004.00283.x

Bahrick, L. E., & Watson, J. S. (1985). Detection of intermodal proprioceptive–visual contingency as a potential basis of self-perception in infancy. *Developmental Psychology, 21*(6), 963-973. doi:10.1037/0012-1649.21.6.963

Barrera, M. E., & Maurer, D. (1981). The perception of facial expressions by the three-month-old. *Child Development, 52*(1), 203-206. doi:10.2307/1129231

Caron, A. J., Caron, R. F., & MacLean, D. J. (1988). Infant discrimination of naturalistic emotional expressions: The role of face and voice. *Child Development, 59*(3), 604-616. doi:10.2307/1130560

Caron, R. F., Caron, A. J., & Myers, R. S. (1982). Abstraction of invariant face expressions in infancy. *Child Development, 53*(4), 1008-1015. doi:10.2307/1129141

Feinman, S. (1982). Social referencing in infancy. *Merrill-Palmer Quarterly, 28*(4), 445-470.

Fernald, A., Pinto, J. P., Swingley, D., Weinberg, A., & McRoberts, G. W. (2001). Rapid gains in speed of verbal processing by infants in the 2nd year. In M. Tomasello, E. Bates, M.

Tomasello & E. Bates (Eds.), *Language development: The essential readings.* (pp. 49-56). Malden: Blackwell Publishing.

Flom, R., & Bahrick, L. E. (2007). The development of infant discrimination of affect in multimodal and unimodal stimulation: The role of intersensory redundancy. *Developmental Psychology, 43*(1), 238-252. doi:10.1037/0012-1649.43.1.238

Flom, R., Whipple, H., & Hyde, D. (2009). Infants' intermodal perception of canine (canis familairis) facial expressions and vocalizations. *Developmental Psychology, 45*(4), 1143-1151. doi:10.1037/a0015367

Gibson, E. J., & Pick, A. D. (2000). *An ecological approach to perceptual learning and development*. New York, NY US: Oxford University Press.

Golinkoff, R. M., Hirsh-Pasek, K., Cauley, K. M., & Gordon, L. (1987). The eyes have it: Lexical and syntactic comprehension in a new paradigm. *Journal of Child Language, 14*(1), 23-45. doi:10.1017/S030500090001271X

Hannon, E. E., & Trehub, S. E. (2005). Metrical categories in infancy and adulthood. *Psychological Science, 16*(1), 48-55. doi:10.1111/j.0956-7976.2005.00779.x

Haviland, J. M., & Lelwica, M. (1987). The induced affect response: 10-week-old infants' responses to three emotion expressions. *Developmental Psychology, 23*(1), 97-104. doi:10.1037/0012-1649.23.1.97

Hirsh-Pasek, K. & Golinkoff, R. (1996). The intermodal preferential looking paradigm reveals emergent language comprehension. In D. McDaniel, C. McKee, & H. Cairns (Eds.), *Methods for assessing childrens' syntax.* Cambridge, MA: MIT Press.

Kahana-Kalman, R., & Walker-Andrews, A. (2001). The role of person familiarity in young infants' perception of emotional expressions. *Child Development, 72*(2), 352-369. doi:10.1111/1467-8624.00283

Keen, R. (2003). Representation of objects and events: Why do infants look so smart and toddlers look so dumb? *Current Directions in Psychological Science, 12*(3), 79-83. doi:10.1111/1467-8721.01234

Kellman, P. J., & Arterberry, M. E. (1998). *The cradle of knowledge: Development of perception in infancy*. Cambridge, MA US: The MIT Press.

Kelly, D. J., Quinn, P. C., Slater, A. M., Lee, K., Ge, L., & Pascalis, O. (2007). The other-race effect develops during infancy: Evidence of perceptual narrowing. *Psychological Science, 18*(12), 1084-1089. doi:10.1111/j.1467-9280.2007.02029.x

LaBarbera, J. D., Izard, C. E., Vietze, P., & Parisi, S. A. (1976). Four- and six-month-old infants' visual responses to joy, anger, and neutral expressions. *Child Development, 47*(2), 535-538. doi:10.2307/1128816

Lewis, T. L., & Maurer, D. (1986). Preferential looking as a measure of visual resolution in infants and toddlers: A comparison of psychophysical methods. *Child Development, 57*(4), 1062-1075. doi:10.2307/1130380

Lewkowicz, D. J., & Ghazanfar, A. A. (2006). The decline of cross-species intersensory perception in human infants. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 103*(17), 6771-6774. doi:10.1073/pnas.0602027103

Lewkowicz, D. J., & Ghazanfar, A. A. (2009). The emergence of multisensory systems through perceptual narrowing. *Trends in Cognitive Sciences, 13*(11), 470-478. doi:10.1016/j.tics.2009.08.004

Ludemann, P. M., & Nelson, C. A. (1988). Categorical representation of facial expressions by 7-month-old infants. *Developmental Psychology, 24*(4), 492-501. doi:10.1037/0012-1649.24.4.492

Nelson, C. A., & Dolgin, K. G. (1985). The generalized discrimination of facial expressions by seven-month-old infants. *Child Development, 56*(1), 58-61. doi:10.2307/1130173

Nelson, C. A., Morse, P. A., & Leavitt, L. A. (1979). Recognition of facial expressions by seven-month-old infants. *Child Development, 50*(4), 1239-1242. doi:10.2307/1129358

Pascalis, O., de Haan, M., & Nelson, C. A. (2002). Is face processing species-specific during the first year of life? *Science, 296*(5571), 1321-1323. doi:10.1126/science.1070223

Poulin-Dubois, D., Serbin, L. A., Kenyon, B., & Derbyshire, A. (1994). Infants' intermodal knowledge about gender. *Developmental Psychology, 30*(3), 436-442. doi:10.1037/0012-1649.30.3.436

Rochat, P., & Morgan, R. (1995). Spatial determinants in the perception of self-produced leg movements in 3- to 5-month-old infants. *Developmental Psychology, 31*(4), 626-636. doi:10.1037/0012-1649.31.4.626

Schmuckler, M. A., & Fairhall, J. L. (2001). Visual-proprioceptive intermodal perception using point light displays. *Child Development, 72*(4), 949-962. doi:10.1111/1467-8624.00327

Serbin, L. A., Poulin-Dubois, D., & Eichstedt, J. A. (2002). Infants' response to gender-inconsistent events. *Infancy, 3*(4), 531-542. doi:10.1207/S15327078IN0304_07

Soken, N. H., & Pick, A. D. (1992). Intermodal perception of happy and angry expressive behaviors by seven-month-old infants. *Child Development, 63*(4), 787-795. doi:10.2307/1131233

Spelke, E. (1976). Infants' intermodal perception of events. *Cognitive Psychology, 8*(4), 553-560. doi:10.1016/0010-0285(76)90018-9

Walker, A. S. (1982). Intermodal perception of expressive behaviors by human infants. *Journal of Experimental Child Psychology, 33*(3), 514-535. doi:10.1016/0022-0965(82)90063-7

Walker-Andrews, A. (1986). Intermodal perception of expressive behaviors: Relation of eye and voice? *Developmental Psychology, 22*(3), 373-377. doi:10.1037/0012-1649.22.3.373

Walker-Andrews, A. (1997). Infants' perception of expressive behaviors: Differentiation of multimodal information. *Psychological Bulletin, 121*(3), 437-456. doi:10.1037/0033-2909.121.3.437

Walker-Andrews, A. (1998). Emotions and social development: Infants' recognition of emotions in others. *Pediatrics, 102*(5), 1268-1271.

Walker-Andrews, A., & Grolnick, W. (1983). Discrimination of vocal expressions by young infants. *Infant Behavior & Development, 6*(4), 491-498. doi:10.1016/S0163-6383(83)90331-4

Walker-Andrews, A., & Lennon, E. (1991). Infants' discrimination of vocal expressions: Contributions of auditory and visual information. *Infant Behavior & Development, 14*(2), 131-142. doi:10.1016/0163-6383(91)90001-9

Werker, J. F., & Tees, R. C. (1984). Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant Behavior & Development, 7*(1), 49-63. doi:10.1016/S0163-6383(84)80022-3

Young-Browne, G., Rosenfeld, H. M., & Horowitz, F. D. (1977). Infant discrimination of facial expressions. *Child Development, 48*(2), 555-562. doi:10.2307/1128653