

Differential Perception of Auditory and Visual Aspects of Emotion in 7- to 15-Month-Old  
Infants

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## ABSTRACT

Infant-directed registers are emotion communication, conveying feelings and intentions to infants and toddlers that may facilitate and modulate attention and language learning. As infants are attracted to emotion, it is essential to understand how infants process emotional information. This study used an infant-controlled habituation paradigm to examine how 7- to 15-month-old infants discriminate changes in visual emotion, auditory emotion, or visual+auditory emotion after being habituated to a bimodal emotion display. The purpose of this study was to examine which modality (facial emotion; vocal emotion) was more salient for infants to discriminate emotions in the context of bimodal stimulation. Infants were habituated to happy audiovisual displays then received four test trials, during which neither source of emotion information was changed (control), just the auditory emotion was changed, just the visual emotion was changed, or both sources of emotion information were changed. It was predicted that infants would show the greatest recovery of attention to a change in visual emotion than when only visual information was changed, but less than when both auditory and visual information were changed. However, the results showed that infants were equally sensitive to all three types of emotion change. These results are discussed in terms of concurrent conceptualizations of how emotion processing is related to negative bias and experience with two emotions.

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## GENERAL AUDIENCE ABSTRACT

When we interact with infants, we convey feelings and intentions to infants that may facilitate and modulate attention and language learning. As infants are attracted to emotions, it is essential that we understand how infants process emotional information. While previous studies have shown that infants are capable of discriminating different kinds of emotions, no known study has been done to examine whether infants would be more sensitive to a change in facial expression or in vocal expression when they experience both facial and vocal expressions together. To examine this, infants were habituated to happy audiovisual displays. Infants then watched four audiovisual displays that were 1) the same happy audiovisual display, 2) audiovisual display with happy face and fearful voice, 3) audiovisual display with fearful face and happy voice, and 4) audiovisual display with fearful face and fearful voice. It was expected that infants would look longer when facial expression was changed than when vocal expression was change, but less than when both facial and vocal expressions were changed. However, the results showed that infants were equally sensitive to a change in facial expression, vocal expression, and both facial and vocal expressions.

## Table of Contents

1.0 – Introduction .....	1
1.1 Infant-directed Register as a Promoter of Attention .....	3
1.2 Emotion as Attention Regulator in ID Register .....	5
1.3 Infants’ Processing of Multimodal Emotion Displays .....	6
1.4 Additional Factors Influencing Infants’ Emotion Processing .....	12
1.5 Purpose of the Study .....	17
2.0 – Methods .....	18
2.1 Participants .....	18
2.2 Materials .....	19
2.3 Procedures .....	22
3.0 – Results .....	24
3.1 Controlling for Speaker Effect and Order Effect During Test .....	24
3.2 Discrimination of Unimodal and Bimodal Emotion Change .....	25
3.3 Relationships between Temperament, Locomotion, Communication Readiness and Emotion Discrimination .....	25
3.4 Habituation Descriptive Statistics .....	25
3.5 Relationship Between Looking Behavior During Habituation and Look Duration on Test Trials .....	26
3.6 Relationship Between Looking Behavior During Habituation and Individual Characteristics .....	27
4.0 – Discussion .....	27
4.1 Limitations .....	31

4.2 Conclusion .....	32
References .....	34
Appendices .....	49
Appendix A – Demographic Questionnaire .....	49
Appendix B – Informed Consent Form .....	50
Appendix C – Infant Behavior Questionnaire – Revised: Very Short Form .....	53
Appendix D – Ages and Stages Questionnaire -3 .....	58
Appendix E – Phrases Used in Events .....	63
Appendix F – Emotional Facial Expressions Used in Events .....	64

### List of Tables

Table 1 – Habituation Descriptive Statistics .....	45
Table 2a – Correlation Between Total Habituation Duration, Number of Habituation Trials, and Look Duration on Test Trials .....	46
Table 2b – Correlation Between Total Habituation Duration, Number of Habituation Trials, IBQ Measures and ASQ Measures .....	46
Table 3a – Correlation Between IBQ Measures and Look Duration on Test Trials .....	47
Table 3b – Correlation Between ASQ Measures and Look Duration on Test Trials .....	47

**List of Figures**

Figure 1 – Looking Durations for Test Trials .....48

## 1.0 – Introduction

Infants rapidly acquire the ability to understand linguistic input and eventually begin to use their own linguistic skills within their first postnatal year. Infants exhibit advances in language development across multiple domains including speech segmentation, word learning, syntax acquisition, and communication. Without doubt, language development during infancy is aided by interaction with others, primarily infants' caregivers (Locke, 2001). When adults are speaking to infants, they typically engage in what is commonly referred to as an infant-directed register even if they do not have previous experience with infants (Fernald, Taeschner, Dunn, Papousek, de Boysson-Bardies, & Fukui, 1989). The typical infant-directed (ID) register comprises higher overall pitch, exaggerated pitch contours, slower tempo, and increased rhythmicity compared to typical adult-directed registers (Fernald & Mazzie, 1991). Moreover, the typical ID register is accompanied by exaggerated facial expressions of emotion by the speaker (Shi, Werker, & Harado, 1997, as cited in Trainor, Austin, & Desjardins, 2000). In fact, some have argued that one of the important functions of the ID register is its ability to convey emotion (Kitamura & Burnham, 1998; Singh, Morgan, & Best, 2002; Trainor, Austin, & Desjardins, 2000). Consequently, it can be argued that the ID register is emotion communication, conveying feelings and intentions to infants and toddlers that may facilitate and modulate attention and language learning.

Advantages of ID register in terms of attention and learning are well documented (e.g., Cooper & Aslin, 1990; Cooper, Abraham, Berman & Staska, 1997; Fernald & Mazzie, 1991). Moreover, attentional and learning processes are differentially modulated by emotion as well as different modalities (Bahrick & Lickliter, 2000; Perry, Swingler, Calkins, & Bell, 2016). Hence, it is important to understand specific ways in which infants process integrated multimodal



presentations of emotion in the context of language. By its nature, the typical ID register is multimodal (Brand, Baldwin & Ashburn, 2002; Gogate, Bahrick & Watson, 2000). In many of their everyday interactions, infants perceive speakers' facial expressions, vocal expressions, and body movements at the same time. However, most of the previous literature has only examined infants' preferences for ID registers and their processing of emotional information within a single modality. For example, most studies have examined ID preferences by providing infants with contrasting voice tracks (ID v. adult-directed [AD]) as they view a non-related visual target, such as a black-and-white checkerboard (e.g., Cooper et al., 1997) whereas other studies have examined infants' discrimination of various emotion expressions using silent static faces (e.g. Serrano, Iglesias, & Loeches, 1995) or infants' discrimination of emotion voices in the presence of blinking lights (Soken & Pick, 1992).

These studies have provided evidence that infants generally prefer ID over AD registers and can discriminate and categorize different emotional expressions visually or auditorily. However, they have not addressed how infants process emotional information when both visual and auditory information are simultaneously available, and within the context of the ID register. Given that infants receive multimodal emotional information in their day-to-day lives (e.g. from faces and voices), it is essential to understand how infants integrate emotional information from different modalities simultaneously. Thus, the purpose of this study is to examine infants' discrimination of emotion information in a multimodal ID context. Specifically, the current study will examine the extent to which older infants can differentially discriminate a change in emotion valence when it is delivered in just one modality of a complex display (visual only, auditory only) compared to both modalities (visual + auditory).

In order to place this investigation within an empirical framework, evidence for infants' preference for the ID register will be presented first, followed by a discussion of what may determine infants' attention toward the ID register. Next, a review of infants' ability to discriminate bimodal affective information is presented, followed by a justification for the current study.

### **1.1 – Infant-directed Register as a Promoter of Attention**

Many studies have shown that ID speech is characterized by higher pitch, more exaggerated pitch contours, slower tempo, and more rhythmicity than typical AD speech (e.g. Benders, 2013; Fernald, 1989). Infants prefer to listen to ID speech compared to AD speech even from a very early age (Cooper, Abraham, Berman, & Staska, 1997; Cooper & Aslin, 1990; Fernald, 1985; Pegg & Werker, & McLeod, 1992; Werker, Pegg, & McLeod, 1994), and it has been suggested that ID speech attracts attention, and promotes language development (Heck, 2015; Stern, Spieker, Barnett, & McKain, 1983; Thiessen, Hill & Saffran, 2005). However, it should be noted that there are developmental contexts in which infants do not develop preferences for ID registers. Specifically, infants with pervasive hearing loss do not develop preferences for ID registers, which speaks to the importance of auditory input in the development of emotional-modulated attention (Bergeson-Dana, 2012).

While many studies have shown infants' increased attention and preference for ID *speech*, there is little work done on whether infants show the same preference for ID *faces*. In fact, very few studies have examined the extension of the characteristics of ID speech in the visual domain (i.e. faces). Like the exaggeration in ID speech, adults' facial expressions were exaggerated in movement, slower in tempo, and longer in duration (Chong, Werker, Russell, & Carroll, 2003; Green, Nip, Wilson, Mefferd, & Yunosova, 2010). Since facial expressions are

synchronized with vocal expressions, it may be possible that infants' preferences for ID speech can be extended to ID faces. Recently, Kim and Johnson (2014) reported that when infants were presented with side-by-side displays of dynamic (i.e., speaking silently) ID and AD faces of a female model, infants demonstrated a preference for the ID face as operationalized by increased looking time.

That infants are sensitive to communication directed to them by others in more than one sensory system is consistent with notions that language learning is a multimodal phenomenon. Gogate, Bahrick, and Watson (2000) hypothesized that communication between mothers and infants provides redundant information across the senses, and named such communication as "multimodal motherese." In the context of word-referent learning, Gogate et al. (2000) found that mothers utilize multimodal motherese to recruit infants' attention. Specifically, these authors found that across all age groups studied (5- to 8-months old, 9- to 15-months old, and 21- to 30-months old infants), mothers utilized temporally synchronized, exaggerated audiovisual communication more often than other types of communication such as asynchronized audiovisual communication, naming an object or action using a static object, or naming an object or action when the infant was holding an object. Thus, Gogate et al. (2000) argued that the primary characteristic of multimodal motherese is temporal synchrony across multiple modalities. Interestingly, these authors also found that the types of communication changed depending on the age of the infants. While synchronized audiovisual communication, or multimodal motherese as the authors proposed, was the primary means of teaching words to infants, their results showed evidence that the use of multimodal motherese decreased as infants aged. Nonetheless, these characteristics of multimodal motherese were found to be prevalent across cultures (Gogate, Bahrick, & Watson, 2000; Gogate, Maganti, & Bahrick, 2015).

As previously discussed, the typical ID register facilitates infants' attention and thereby promotes learning. In the context of word-object learning, Gogate, Bolzani, and Betancourt (2006) examined whether the use of multimodal motherese and infants' attention to object naming predicted 6- to 8-months old infants' learning of word-object relations. These authors found that infants attended to target objects more and showed better learning of word-object relations when mothers used multimodal motherese. Thus, the ability of multimodal ID registers to enhance infants' emerging linguistic skills is supported by the literature. But what of infants' learning about emotions and the ability of emotion information to mediate language learning?

### **1.2 – Emotion as Attention Regulator in ID Register**

It is possible that emotion information embedded in typical ID registers is an important component for promoting attention and learning. Trainor, Austin and Desjardins (2000) argued that the information transmitted through ID speech is primarily emotional in its nature. In contrast to previous studies, these authors found few differences in acoustic features of ID and AD speech when emotional valence was equated, arguing that differences across these registers arose from vocal expression of emotion rather than simply whether an infant or an adult was the intended listener. Interestingly, Kitamura and Burnham (1998) found that infants preferred high affect to low affect speech when pitch was equated and showed no preference for higher pitch to lower pitch speech when affect was equated. Singh, Morgan, and Best (2002) examined 6-month-old infants' preferences for either ID or AD speech in a series of experiments that manipulated emotional valence. These authors found that infants did not show a preference for ID speech compared to AD speech when emotion was held constant for both sets of utterances. Furthermore, when AD speech stimuli contained more positive affect than ID speech, infants actually showed a preference for AD speech. Since ID speech is characterized as more

emotional, infants' preference for ID speech may be due to emotionality alone. In this same vein, Kim and Johnson (2013) examined whether 6-month-old infants' preferences for ID faces is due to positive visual emotion. In their first experiment, these authors found that infants showed no preference for ID faces when the positive emotion of ID and AD faces was held constant. In their second experiment, infants showed preferences for happy AD faces over sad ID faces. Kim and Johnson (2013) concluded that infants' visual preference for ID faces is mediated by the presence of positive emotion.

Taken together, it appears that infants' preference for caretakers' ID styles is largely attributable to its positive emotional valence across at least two sensory systems: vision and audition. Kim and Johnson (2013) argued that "directedness" of faces (i.e. infant-directed or adult-directed face) might become less recognizable when speech is withheld from the stimuli, forcing infants to direct their attention to the emotions expressed in the face. Because it is uncommon for infants to experience silent ID registers in their daily interactions, it is possible that infants perceive emotional information across modalities that attract and direct their attention, but also that they are particularly dependent on either visual emotion information, auditory information, or both. Thus, given the potential importance of emotion as an attention regulator in the ID register, it is necessary to investigate how likely infants are to discriminate changes in emotion valence in visual alone, auditory alone, and a visual+auditory context.

### **1.3 – Infants' Processing of Multimodal Emotion Displays**

Many studies have shown that infants can perceive emotion through unimodal visual or unimodal auditory stimulation. For example, 4-month-olds discriminate changes in static facial expressions of emotion (Amso, Fitzgerald, Davidow, Gilhooly, & Tottenham, 2010; Kotsoni, De Haan, & Johnson, 2001; Nelson, Morse, & Leavitt, 1979; Serrano, Iglesias, & Loeches, 1995).

Other studies provide evidence that infants can discriminate different vocal emotion expressions (Blasi et al., 2011; Cheng, Lee, Chen, Wang, & Decety, 2012; Grossmann, Striano, & Friederici, 2005; Grossmann, Oberecker, Koch, & Friederici, 2010). Even a few days after birth, newborns show evidence that they can discriminate positive emotion from negative emotion in response to emotionally spoken syllables (Cheng et al., 2012). Between the ages of three to seven months, cortical activation elicited by sad vocalizations was greater than that elicited by emotionally neutral vocalizations in the insula and orbitofrontal cortex, which implied that young infants are capable of detecting emotional signals (Blasi et al., 2011). Furthermore, by 7 months of age, infants show differential brain activations to angry and happy vocal prosody (Grossmann et al., 2005; Grossmann et al., 2010).

Although the results from studies examining infants' abilities to perceive unimodal emotion advance our understanding of the development of emotional information processing, it is, however, rare for infants to experience only unimodal emotional information. In naturalistic contexts, infants' interaction with others involves the perceptual integration of multimodal information. For example, it is rare for infants to perceive only faceless emotional utterances or voiceless emotional faces.

Several studies have suggested that infants discriminate emotion in multimodal contexts (Caron, Caron, & MacLean, 1988; Flom & Bahrick, 2007; Walker-Andrews & Lennon, 1991). For example, in an effort to understand how infants utilize multiple sensory information to discriminate emotions, Flom and Bahrick (2007) conducted a series of experiments using an infant-controlled habituation paradigm. In the first experiment, 4-, 5-, and 7-month-old infants showed evidence that infants across all ages can discriminate happy, sad, and angry dynamic faces with synchronized voices. In their second experiment, these authors first habituated infants

to a static neutral face with an accompanying voice track that conveyed a positive or negative emotion. They then changed the auditory expression of emotion while continuing to show the static neutral face. The authors called this manipulation ‘unimodal auditory’ because “affect was conveyed only by unimodal acoustic information, and the static face provided no temporal redundancy or visual information specifying affect” (p. 244). The results showed that only the 5- and 7-month-olds discriminated the change in vocal emotion. Next, Flom and Bahrick (2007) assessed infants’ discrimination of emotion on the basis of unimodal visual information. In their third experiment, the authors presented infants with dynamic silent faces that conveyed emotion (i.e., no voice tracks). The results revealed that only 7-month-old infants discriminated a change in visual emotion. Collectively, the results of these experiments provide evidence that early in development redundant bimodal stimulation fosters perception of emotional information, and with increasing age (i.e., by 7 months of age), attention becomes more flexible and infants are able to perceive emotional information under conditions of both unimodal and bimodal stimulation.

Further evidence from studies that examined whether infants could match emotion across modalities suggest that infants in fact can integrate two different sources to represent one emotion. Studies have revealed successful face-voice matching of emotion in infants between 3.5 and 7 months of age (Kahana-Kalman & Walker-Andrews, 2001; Soken & Pick, 1992; Walker-Andrews, 1982, 1986, 1997 for reviews). For example, Walker-Andrews (1982) examined 5- and 7-month-old infants in a series of experiments using the intermodal preference technique (c.f., Spelke, 1976) and found that both 5- and 7-month-old infants looked longer to one of two static facial expressions (e.g., happy v. sad) when a voice track matching the emotion valence was also available. Even when the voice track was made asynchronous with a moving face track by five

seconds, 7-month-old infants were able to detect common affect indicated by an increase in looking time to the affectively concordant display. In addition, Walker-Andrews (1986) concealed a lower part of the model's face to prevent infants from matching lip movements to the voice. Nonetheless, 7-month-old infants preferentially looked at the affectively concordant display.

Taking these results further, Soken and Pick (1992) presented infants with a modified "point light" display of one facial expression of emotion with the voice track. The point light display conceals facial feature information and conveys only facial motion cues through bright reflective spots that were attached to a model's joints. In one experiment, 7-month-olds were presented with happy and angry visual displays shown side by side while one of the corresponding voice tracks was played. In the second experiment, 7-month-olds viewed the same displays, but the vocal track was 5 seconds out of synchrony. In both experiments, the 7-month-olds looked longer at the affectively concordant point-light displays than at the affectively discordant displays, showing that infants were able to detect congruent affective relation between face and voice based on motion information portrayed by point-light displays.

Several electrophysiological studies also support the notion that infants can detect common emotion displays across modalities (e.g., Grossmann, Striano, & Friederici, 2006; Otte, Donkers, Braeken, & Van den Bergh, 2015). For example, Grossmann, Striano, and Friederici (2006) conducted an ERP study in which 7-month-old infants were presented with a static facial expression (happy or angry) and either congruent and incongruent vocal expressions of emotion. Under the assumption that an enhanced negative component (Nc) reflects increased attention to unfamiliar stimuli and an enhanced positive component (Pc) reflects increased attention to familiar stimuli, infants displayed a larger amplitude Nc when emotionally incongruent stimuli



were shown than when emotionally congruent stimuli were shown. Conversely, infants displayed a larger amplitude Pc when emotionally congruent stimuli were shown. These authors suggested that 7-month-old infants can integrate emotional information across modalities and recognize common affect in the face and voice.

However, questions remain as to whether infants are differentially attuned to either visual or auditory emotional information or whether they are more likely to discriminate a change in emotion when both modalities convey relevant information. Grossmann et al. (2006) found that the amplitudes of infants' Nc not only differed between congruent and incongruent face-voice pairs, but also between two different types of incongruent pairs. When a happy face was presented with an angry voice, the Nc amplitude was more negative in its amplitude than when an angry face was presented with a happy voice. Grossmann et al. (2006) interpreted these results in terms of infants' familiarity to happy expressions, arguing that infants' expectation to hear a happy voice with happy face is greater than their expectation to hear an angry voice with angry face because they have more experience with happy emotion expressions. This finding suggests that infants may allocate attention to visual and auditory information differently depending on the valence of the emotions. Interestingly, infants prior to the onset of crawling (around 10 months of age) are predominantly exposed to others' happy expressions (Campos, Anderson, Barbu-Roth, Hubbard, Hertenstein, & Witherington, 2000). Considering the evidence that infants are already capable of discriminating different kinds of emotion, and that happy emotion facilitates infants' learning of word-object relations (Heck, 2015) and attention, understanding how infants integrate two different sources of happy emotion information will extend our knowledge about how infants process bimodal emotion information.

More recently, Otte et al. (2015) found that the modulation effect of visual information processing on auditory information processing differed depending on the valence of visual stimuli. Specifically, 9-month-old infants were primed with a happy or a fearful static face and listened to either a happy or a fearful vocalization. When fearful visual faces were presented, infants responded with larger amplitudes P150 and P350 and smaller amplitudes N250 and N450 to emotional auditory stimuli (both happy and fearful vocalizations), compared to these same components in the presence of happy faces. As increased positivity at P150 and P350 often is associated with allocation of attention to auditory information and a change in the environment, it can be suggested that a fearful face increased attention to auditory stimulus regardless of its valence. Thus, the results suggest that visual information plays a crucial role in the integration of bimodal emotional information, especially when fearful visual information is available.

Moreover, while infants were able to detect emotional inconsistency between visual and auditory emotions when the visual emotion was anger (Grossmann et al., 2006), the infants failed to show any evidence that they detected emotional inconsistency between visual and auditory emotions when the visual emotion was fear (Otte et al., 2015). It is possible that anger and fear capture infants' attention differently even though they both are under the category of negative emotion.

Kotsoni, de Hann, and Johnson (2001) found that infants discriminated a happy face from a fearful face following habituation to a happy face. However, they also found that following habituation to a fearful face, infants showed no recovery of attention to a happy face. Among many possibilities, these authors suggested that infants show increased interest to fear because they "are beginning to perceive the meaning of the fearful expression at this age and respond ... with increased vigilance" (p. 1123). Supporting this notion, it has been shown that fear becomes effective as a behavior regulator in a social referencing context (Mumme, Fernald, & Herrera,

1996; Vaish & Striano, 2004) and captures infants' attention for information processing (Leppänen & Nelson, 2009; Otte et al., 2015).

Nonetheless, evidence shows that infants can detect common affect across modalities and integrate them as one unique event. Additionally, evidence shows that infants can discriminate not only unimodal emotion, but also bimodal emotion. However, further examination is needed to understand whether one modality is more salient than the other when infants integrate two different sources of information.

#### **1.4 – Additional Factors Influencing Infants' Emotion Processing**

In an effort to understand infants' emotion processing, this study will also examine two additional factors that may influence infants' ability to process emotional information from others. In their review, Leppanen and Nelson (2009) suggested that infants' representations of species-typical facial expressions are “shaped by individual-specific experiences and the frequency and intensity of certain facial expressions in the rearing environment” (Leppanen & Nelson, 2009, p. 43). This reasoning can also be applied to the variation in emotional experiences that may affect infants' emotional processing. It is possible that infants' developmental changes and individual characteristics shape their experiences with emotion by influencing their environment. Given the importance of exposure to emotional interactions for infants' ability to process emotional information, the current study will also examine infant temperament and self-locomotion as moderators of emotion discrimination. The rationale for examining these factors is provided below.

**Infant temperament and its influence on emotion processing.** The first potential developmental moderator on emerging emotion perception is infant temperament. Temperament is defined as “constitutionally based individual differences in reactivity and self-regulation, with

‘constitutional’ referring to the person’s relatively enduring biological make-up, influenced over time by heredity, maturation, and experience” (Rothbart, 1989, p. 59). In other words, temperament refers to infants’ general emotional styles. Recent neurological studies provide some link between infants’ ability to process emotional expressions differentially depending on their temperament styles. For example, Martinos, Matheson, and de Haan (2012) examined whether the temperamental traits of 3- to 13-month-old infants influenced their attention to emotion displays. Using an ERP method, these authors found that Nc, an event-related potential component whose amplitude reflects the allocation of attention, was greater to happy faces than to fearful faces when infants were high on negative emotionality (Martinos, Matheson & de Haan, 2012). In contrast, infants with higher self-regulatory ability showed greater Nc amplitude to fearful faces than to happy faces, possibly because they exert greater effort toward controlling attention and regulating their emotions when viewing the expression of fear.

In a recent study showing a different pattern of results, 7-month-old infants were exposed to happy faces in an fNIRS protocol (Ravicz, Perdue, Westerlund, Vanderwert, & Nelson, 2015). These authors found that infants with lower negative emotionality showed greater hemodynamic responses to happy faces, whereas infants with greater negative affect showed lower hemodynamic responses to happy faces (in contrast to higher amplitude Nc in Martinos, Matheson & deHaan, 2012). Such inconsistency may reflect the nature of the primary measures in these two methodologies (i.e., ERP v. fNIRS). In ERP, the Nc component reflects orienting or initial attention allocation and it is possible that infants who are more negative in affective styles find happy adult expressions less familiar (i.e., more novel). However, the same kind of infants (those higher in negative affect) may not continue to attend to and process positive expressions

with the same level of effort as infants with more positive affect (i.e., they show attenuated BOLD responses to happy faces).

In a slightly different vein, behavioral evidence suggests that infants' temperament relates in a reciprocal fashion with responses from their caretakers (Kiff, Lengua, & Zalewski, 2011). Studies have shown that infant temperament shapes parental perceptions of their infants (Boukydis & Burgess, 1982; Jacobson & Melvin, 1995), and maternal behavior and parenting stress (Mantymaa, Puura, Luoma, Salmelin, & Tamminen, 2006; Schoppe-Sullivan, Mangelsdorf, Brown, & Sokolowski, 2007). For example, Jacobson and Melvin (1995) examined mothers' rating of their infants' temperament styles between those whose infants had colic and those whose infants did not have colic. Mothers of infants with colic not only rated their infants as more difficult, but also reported that they were bothered more by their infants' negative moods. In this case, infant temperament guided emotional reactions from the caregiver, thereby negatively influencing the emotional environment for themselves. Additionally, it should also be noted that parental perception of infant temperament could be influenced by parents' own individual characteristics such as depression (McGrath, Records, & Rice, 2008) and childhood experiences (Leerkes & Crockenberg, 2006).

Interestingly, Pauli-Pott, Mertesacker, Bade, Haverkock, and Beckmann (2003) examined whether maternal perceptions concerning infants' temperament characteristics (positive emotionality, negative emotionality, and fearfulness) were predictive of the subsequent development of infant temperament. These authors found that mothers' perceptions of their infants' positive emotionality at 4 months of age predicted infants' positive emotionality at 8 months of age. Mothers' perceptions of negative emotionality at 8 months of age predicted infants' negative emotionality at 12 months of age, and mothers' perceptions of infants'

fearfulness at age of 4- and 8-months predicted infants' fearfulness at ages 8- and 12-months, respectively. These findings can be interpreted in at least two ways. One, parents are remarkably astute at perceiving stable temperament characteristics of their infants over a wide age range, and/or two, parents actually shape emerging temperament characteristics according to their perceptions. In other words, parents, based on their perceptions of their infants' characteristics early on, adapt their own behaviors toward their infants, thereby providing a specific context that infants experience. Infants, in turn, may learn to adjust their behaviors according to these contexts.

Some evidence that infants are influenced by the context provided by parents in response to infants' temperament is provided by de Haan, Belsky, Reid, Volein, and Johnson (2004). In this study, the authors examined the role of experience indirectly by investigating the relationship between mothers' positive and negative personality dispositions and 7-month-olds' processing of happy and fearful facial expressions. de Haan et al. found that infants with highly positive mothers looked longer at fearful than happy expressions, whereas mothers' negative personality disposition did not show any influence on infants' looking patterns. Thus, these findings suggest that emotional experiences, especially positive experiences from mothers, contribute to the development of emotion processing. The current study will obtain infant temperament ratings from the mothers in order to examine associations between infant temperament and infants' emotion discrimination patterns.

**Infant self-locomotion and its influence on emotion processing.** The second developmental factor that may influence infants' emotion processing is their own experience with self-locomotion. Locomotion is defined as self-produced movements that allow intentional approach to objects and people of interest and initiation of independent exploration (Hendrix &

Thompson, 2010; Karasik, Tamis-LeMonda, & Adolph, 2014). Self-locomotion allows infants to access a larger area of space (Campos et al., 2000), enhances language development (Walle & Campos, 2014), and changes optic flow perception (Kretch, Franchak, & Adolph, 2014; Uchiyama, Anderson, Campos, Witherington, Frankel, Lejeune, & Barbu-Roth, 2008). But how would self-locomotion be related to emotion experience? Primarily, the advent of self-locomotion may effectively increase the range of emotion expressions from caretakers that are directed toward the infant, in particular the more negatively valenced emotions like fear.

In a longitudinal study, Green, Gustafson, and West (1980) observed infants when they were 6-, 8-, and 12-months of age to examine the effect of changes in social and motor capabilities on daily social interactions with their mothers. Their results showed that as infants became older, they engaged more in activities that were prohibited and/or redirected by mothers, initiated more frequent social exchanges, which in turn attracted mothers' attention and afforded mothers more opportunities to respond to infants' activities. Consistent with these results, Clearfield (2011) also found that the level of infants' self-locomotion changed the quality of their social behaviors. While Clearfield's findings focused on the difference in social behavior of crawlers and walkers, it was emphasized that as self-locomotion develops, infants' social interaction with others gets more sophisticated. However, while Green, Gustafson and West (1980) described the development of self-locomotion as maturational in nature, Clearfield (2011) pointed out that a transition to an advanced form of self-locomotion (e.g. crawling and/or independently walking) serves as "a control parameter that results in a reorganization of infant experiences" (p. 24). In other words, it could be argued that self-locomotion development allows other processes such as perception, attention, and social behaviors to change. Thus, the

development of self-locomotion can be one of the pivotal points for infants to expand the repertoire of social interaction with others.

As mentioned above, as self-locomotion emerges the range of infants' interactions broadens, expanding infants' emotional experiences. For example, infants who initiated exploration of the environment by their own agenda had mothers who showed more negative emotion in both facial expressions and vocal expressions (Campos et al., 2000). Moreover, the intensity, frequency, and type of positive feedback from mothers to infants decreased as infants' level of locomotion improved (Biringen, Emde, Campos, & Appelbaum, 1995; Karasik, Tamis-LeMonda, & Adolph, 2014). Given the evidence that locomotion development influences infants' emotional experience from the environment, the current study will examine the association between self-locomotion development and infants' emotion discrimination. As Campos et al. (2000) claimed, locomotion alone "is not a causal agent" (p. 151) that changes infants' development. In this view, the development of locomotion changes the environment, and facilitates changes in experience. Because infants' emotional experience is expanded in its variability, frequency, and intensity due to self-locomotion, it may be informative to examine the influence of infants' self-locomotion on their ability to discriminate emotion expressions.

### **1.5 – Purpose of the Study**

The current study was designed to examine whether infants differentially discriminate changes in visual emotion, auditory emotion, or visual+auditory emotion after being habituated to a bimodal emotion display. Specifically, the study aimed to examine which modality is more salient for infants to discriminate emotions in the context of bimodal stimulation. Infants from 7 to 15 months of age were tested because by 7 months of age, infants can detect common affect across faces and voices even without temporal synchrony (Flom & Bahrick, 2007; Grossmann,



2010), and can discriminate unimodal information, and by 10 months of age, infants experience a change in his or her mother-infant relationship (Campos et al., 2000).

Infants were presented with an audiovisual display that consists of a static emotional expression of a female model with a concomitant vocal track of the same emotion in an infant-directed manner (i.e., happy). The audiovisual (AV) display continued to play as long as infants look at it, and repeated until infants were habituated to the AV display (the criterion for habituation is presented below). Once infants were habituated to the AV display, infants were presented with four test trials. During the test, infants were presented with the familiar AV display (Fam), an AV display in which only auditory emotion was changed (A-only), an AV display in which only visual emotion was changed (V-only), and an AV display in which both visual and auditory emotion were changed (AV). In this study, infants' looking duration to the presentations during test was used as an index of emotion discrimination. It was predicted that while infants would discriminate a change of emotion in all trials, infants' level of attention to a trial which changed only visual emotion would be greater than to a trial which changed only auditory emotion, but less than to the trial which changed both visual and auditory emotions after infants habituated to a happy AV display.

## **2.0 – Method**

### **2.1 – Participants**

Eighteen infants (13 males, 5 females;  $M_{age} = 41.94$  weeks, age range: 28 - 60 weeks) were included in the final sample. An additional 7 infants were tested but were not included due to fussiness ( $n = 5$ ), equipment error ( $n = 1$ ), and experimenter error ( $n = 1$ ). All infants included in the final sample were healthy (by parental report). All infants were full-term and above 5.5 lbs at birth. Participants were recruited through a database maintained in the Developmental

Research Suite in the Department of Psychology at Virginia Tech, through flyers, and referrals. The sample was representative of the demographics in the surrounding area (Caucasian:  $n = 14$ , African American:  $n = 1$ , other:  $n = 3$ ). Parents were highly educated ( $n = 17$  with both parents having at least a college degree), married ( $n = 18$ ), and mostly middle- to upper-middle-class ( $n = 16$  combined income over \$80,000/year). All participants received a certificate of participation and between \$10 - \$20 as a thank you for their participation. Six initial participants received \$10 in compensation for their participation in the study, and the remainder received \$20.

## 2.2 – Materials

**Informed consent and demographic questionnaire.** Parents received and signed two copies of an informed consent and complete a demographic questionnaire to provide descriptive information of the sample for this experiment (see Appendix A and B).

**Infant Behavior Questionnaire – Revised: Very Short Form (IBQ-R: VSF).** Parents completed the Infant Behavior Questionnaire-Revised: Very Short Form (IBQ-R: VSF; Gartstein & Rothbart, 2003; see Appendix C), which is a measure of infant temperament. It includes 37 questions about the frequency or intensity of certain infant behavior. The measure uses a Likert scale, ranging from 0 (“Never”) to 7 (“Always”). Three separate factors have been linked with the items from this measure: Surgency/Extraversion, Negative Affectivity, and Orientation/Regulation. The questionnaire has been found to have high internal reliability, with Cronbach’s alpha calculated to be .92 for Surgency/Extraversion and .91 for Negativity Affectivity, and Orientation/Regulation (Gartstein & Rothbart, 2003).

**Age and Stage Questionnaire – 3 (ASQ-3).** Parents completed one section (appropriate for their age) of the Age and Stages Questionnaire – 3 (ASQ-3; Bricker & Squires, 2009; see Appendix D). The ASQ identifies children who are at risk of social or developmental delays. The

gross motor scales contain 6 items. The measure is scored on a Likert scale where 0=Not yet, 5=Sometimes, and 10=Always. The ASQ has been found to have good to acceptable internal reliability, with Cronbach's alpha calculated to be ranged from .51 to .87, as well as acceptable concurrent validity with similar measures (Squires, Twombly, Bricker, & Potter, 2009).

**Audiovisual displays.** AV displays consisted of static facial expressions of female models portraying two different emotions (happy and fearful; see Figure 1) and concomitant vocal tracks of either the same emotion (congruent) or a different emotion (incongruent). The two visual emotions were selected (happy and fear) from the validated NimStim Face Stimulus Set (<http://www.macbrain.org/resources.htm>) as the visual emotional component. Happy and fear vocal expressions of two actresses citing several phrases (Heck, Panneton, & Mills-Smith, 2015; see Appendix E) was used as the auditory emotional components. These components were rated by undergraduates for emotion type and emotion intensity (Heck et al., 2015). It was found that target emotions were identified correctly 99% of the time, and were not different from each other in terms of intensity. In order to ensure that effects are not primarily due to the specific female face and vocal track, two similarly rated NimStim faces (Tottenham et al., 2009) and vocal tracks were used. During habituation, four displays comprised congruent emotions vocally and visually (i.e., two happy facial expression and happy vocal track; two fearful facial expression and fearful vocal track). For testing, these displays were recombined to create the incongruent emotions visually or vocally (i.e., happy facial expression and fearful vocal track; and fearful facial expression and happy vocal track).

These AV displays were edited together by using Adobe Premiere Elements 12. The AV displays were approximately 20 seconds in duration (but were looped continuously until the infant looks away from the screen) and approximately 33 cm x 27 cm in size (resulting in a

visual angle of 23 degrees x 19 degrees). All voices were normalized in volume. Playback to the infants was between 70-72 dB SPL as measured at the head of the infant during the procedure (a level that was consistent with casual conversational speech). During the habituation phase, each infant was presented with congruent AV displays. During the testing phase, the infant was presented with the same congruent audiovisual display that was presented during the habituation phase, two incongruent audiovisual displays, and one congruent audiovisual display that is expressing a different emotion from that experienced during habituation (all by the same actress/speaker within each individual session).

**Apparatus.** The audiovisual movies were displayed on a 32-inch NEC brand LCD monitor with speakers on both sides hidden by a black cloth panels. A remote-controlled Panasonic camera (WV-cs574) was positioned approximately 12 cm above the monitor. The camera position was controlled in an adjacent room by an observer so that the infant was fully visible to the observer at all times during the session. Each session was viewed live on a GE television/VCR, and was recorded by a Sony DVD player. The audiovisual events were controlled via a MacBook Air computer, using Habit2 presentation software (Oakes, Sperka, & Cantrell, 2015). Habit2 required input from the computer running the experiment to determine the infant's looking behavior. The primary observer monitored the infant's visual fixations by pressing a key on the computer while the infant fixates on the center event and releasing the key when the infant looks away from the center event. In this way, the infant's looking behavior determined when trials start and end, and when the infant habituates. The primary observer controlling Habit2 was not able to see or hear what the infant was experiencing to reduce bias during each session. Infants sat in a high-chair for the experiment, and their parent was instructed to not interact directly with the infant during the experiment unless the infant became upset. If an

infant refused to sit in the high-chair, then the infant sat on his or her parent's lap. Only then the parent wore black-tinted glasses and Bose QC15 noise-canceling headphones through which soft, vocal music was played. The purpose of the glasses and headphones were to keep the parent unaware of the specific sounds and facial expressions that the infant was seeing and hearing so that the parents' reactions would not influence the infants' reactions to the critical change in emotional expressions.

### **2.3 – Procedure**

Upon arrival to the laboratory, located in the Department of Psychology at Virginia Tech, the infant and parent(s) or legal guardian(s) was guided to the waiting room. A brief summarization of the experiment was provided to the parent or legal guardian, and the informed consent was obtained. Also, during this time, a demographic questionnaire was provided to the parent to obtain the family's background information. While the parent or legal guardian was completing the informed consent and questionnaire in the same room, the experimenters interacted with the infant to have a "warming up" period so that the infant and parent were comfortable prior to testing.

Next, the parent and infant were guided to the testing room. The infant participated in an infant-controlled habituation procedure (Horowitz, Paden, Bhana, & Self, 1972). The infant was habituated to one of two female models, who was assigned to the infant randomly, conveying one of two congruent emotional expressions in bimodal audiovisual speech. During the habituation phase, the infant experienced a series of trials to familiarize them to the Happy AV display. Each trial began when the infant looked at a centering event on the monitor (a smiling and laughing infant in the center of the display) and the trial ended when the infant looked away from the monitor for at least 1.5 seconds (determined by the trained observer via Habit2

software). Once a trial ended, the centering event reappeared until the infant looked at the centering event and then the same habituation event began again. Each trial continued as long as the infant looked at the screen. The audiovisual display played in a loop if the infant continued to look. The habituation sequence continued until the infant reached a habituation criterion of a decline in the average looking time of the first two trials by 50% (i.e.,  $\text{Habituation} = (\text{Trial}_1 + \text{Trial}_2/2)/2$ ) across two consecutive trials (e.g.,  $\text{Trial}_x + \text{Trial}_{x+1}/2 < \text{Habituation}$ ). If this criterion was not met on the second set of two consecutive trials (e.g. trial 3 and trial 4), the average looking time of the following two consecutive trials (trial 4 and trial 5) was compared with Habituation and so on; thus, the criterion was based on the running average of look durations across consecutive habituation trials. If the habituation criterion was not met by the end of the 20<sup>th</sup> habituation trial, then the infant received four test trials. In this case, the experiment session was considered as a non-successful session and the infant was not included as the final sample.

Once the habituation criterion was met, the infant received four test trials. During the familiar (F) trial, the infant received the same congruent AV display seen during the habituation phase. During the auditory emotion change (A) trial, the infant received the same face conveying the same emotion, and the same voice but conveying a different emotion. During the visual emotion change (V) trial, the infant received the same voice conveying the same emotion, and the same face but conveying a different emotion. Finally, during the audiovisual emotion change (AV) trial, the infant received the same face and voice but both conveying a different emotion.

The order of these four trials was semi-counterbalanced by creating two different orders of test trials. F trials always occurred first in order to test for spontaneous regression of looking recovery. AV trials always occurred last to avoid carry-over effects. However, A and V test trials were randomly presented across infants within each of the two emotion conditions. Thus, the

order of test trials varied only by whether the infants experienced A trial or V trial first, after F trial was presented.

### **3.0 – Results**

#### **3.1 – Controlling for Speaker Effect and Order Effect During Test**

To examine whether the specific speaker used during the session influenced infants' attention during test, a 2 x 4 mixed ANOVA with Speaker (2: SpeakerA; SpeakerB) as a between-subject factor and Trial Type (4: Fam, A-only, V-only, AV) as within-subject factor on looking duration was performed. There was a significant main effect of Trial Type,  $F(3, 48) = 2.74$ ,  $p = .05$ ,  $\eta_p^2 = .15$ , but no significant main effect of Speaker,  $F(1,16) = .80$ ,  $p = .39$ ,  $\eta_p^2 = .05$ , and no significant Speaker x Trial Type interaction,  $F(3,48) = .40$ ,  $p = .75$ ,  $\eta_p^2 = .02$ . Thus, Speaker conditions were collapsed in subsequent analyses.

To examine whether test order influenced recovery of attention, average looking times on test trials as a function of whether A-only or V-only occurred first (after habituation) were compared. A 2 x 4 mixed ANOVA with Test Order (2: Auditory First, Visual First) as between-subject factor and Trial Type (4: Fam, A-only, V-only, AV) as the within-subject factor on looking duration was performed. A significant main effect of Trial Type was found,  $F(3,48) = 3.20$ ,  $p = .03$ ,  $\eta_p^2 = .35$ . Moreover, a significant main effect of Test Order was found,  $F(1,16) = 6.20$ ,  $p < .02$ ,  $\eta_p^2 = .28$ . It indicated that the average looking duration across all trials in the A-only First test order ( $M = 8.41$ ,  $SE = 1.37$ ) was significantly shorter than the average looking duration across all trials in V-only First test order ( $M = 13.51$ ,  $SE = 1.53$ ). However, there was no significant Test Order x Trial Type interaction,  $F(3,48) = 1.43$ ,  $p = .25$ ,  $\eta_p^2 = .08$ . Thus, Test Order was collapsed for all subsequent analyses. The overall main effect of Test Order will be interpreted in the Discussion.

### 3.2 – Discrimination of Unimodal and Bimodal Emotion Change

Of primary interest was whether infants discriminated a change in emotion from habituation when just the vocal emotion was changed, just the facial emotion was changed, or both were changed. A repeated-measures ANOVA with four test trials (Fam, A-only, V-only, AV) as a repeated-measure factor was conducted. There was a significant main effect of trial,  $F(3, 45) = 2.84, p = .047, \eta_p^2 = .14$ . Further analyses using paired-samples *t*-tests showed that there was a significant difference between Fam ( $M_F = 5.53, SD_F = 2.21$ ) and all other test trials: (i) A-only ( $M_A = 11.23, SD_A = 8.86$ ),  $t(17) = -2.60, p = .02$ ; (ii) V-only ( $M_V = 12.24, SD_V = 7.00$ ),  $t(17) = -3.77, p = .002, d = .89$ , and (iii) AV ( $M_{AV} = 13.69, SD_{AV} = 14.41$ ),  $t(17) = -2.38, p = .03, d = .56$ . However, there were no significant differences between the test trials that involved a perceptual change: (i) A-only ( $M_A = 11.23, SD_A = 8.86$ ) and V-only ( $M_V = 12.24, SD_V = 7.00$ ),  $t(17) = -.32, p = .76, d = .07$ ; A-only ( $M_A = 11.23, SD_A = 8.86$ ) and AV ( $M_{AV} = 13.69, SD_{AV} = 14.41$ ),  $t(17) = -.87, p = .40, d = .21$ ; and V-only ( $M_V = 12.24, SD_V = 7.00$ ) and AV ( $M_{AV} = 13.69, SD_{AV} = 14.41$ ),  $t(17) = -.36, p = .72, d = .08$  (see Figure 2). Thus, the overall pattern shows significant recovery of attention to all types of change trials; this will be interpreted more fully in the Discussion section below.

### 3.3 – Habituation Descriptive Statistics

Table 1 presents descriptive statistics for infants' performance during habituation. Comparison between the average look duration of the last two habituation trials and the look duration on F trial using paired-samples *t*-test did not find any spontaneous regression toward the mean,  $t(17) = 1.49, p = .16, d = .35$ .

### 3.4 – Relationship Between Looking Behavior During Habituation and Look Duration on Test Trials



To examine whether infants' habituation pattern was related to look duration on test trials, bivariate correlations were calculated for the number of habituation trials, the time to reach habituation, and look duration on test trials. Both number of habituation trials and the time to reach habituation were not correlated with the look duration on test trials (see Table 2a).

### **3.5 – Relationship Between Looking Behavior During Habituation and Infant**

#### **Characteristics**

In addition, to examine how infants' individual characteristics were related to infants' habituation pattern, bivariate correlations were calculated for the number of habituation trials, the time to reach habituation, and temperament (measured by IBQ). No measures of temperament were significantly correlated with the number of habituation trials and the time to reach habituation (see Table 2b).

Moreover, additional bivariate correlations were calculated for the number of habituation trials, the time to reach habituation, and infants' self-locomotive and communicative abilities (measured by ASQ). A total of five ASQ was used to measure infants' self-locomotive ability and communicative ability. Each ASQ measure was age-appropriate (7 months – 8 months and 3 weeks; 9 months – 10 months and 3 weeks; 11 months – 12 months and 3 weeks; 13 months – 14 months and 3 weeks; and 15 months – 16 months and 3 weeks). Because the current study used 5 ASQs, the scores from each subscale were calculated cumulatively according to the infant's age. It was assumed they met the developmental motor and communicative milestones of the previous ages, thus those scores were added to their score. For example, if a 9-month-old infant scored 40 on Gross Motor subscale, then the score of 60 was added to the infant's score because it was assumed that the infant has already achieved his or her developmental motor milestone of that of 7- to 8-month-olds. The scoring procedure was repeated for the Communication scores. The

results showed that there was no significant correlation between the number of habituation trials, the time to reach habituation, and infants' self-locomotive and communicative abilities (see Table 2b).

### **3.6 – Relationships between Temperament, Locomotion, Communication Readiness and Emotion Discrimination**

In addition to the discrimination results presented above, this study also attempted to relate other measures of infants' capabilities and experiences to their multimodal sensitivity in discriminating visual, auditory, and visual+auditory emotion. Bivariate correlations were calculated between the looking durations on test trials and the three subscale scores of the temperament measure (i.e., IBQ): surgency, negative affectivity, and orientation/regulation (see Table 3a). Surgency was significantly negatively correlated with the look duration on A-only ( $r = -.55, p = .02$ ), but it was significantly positively correlated with average look duration on V-only ( $r = .58, p = .01$ ). No other measures of temperament were correlated with the look duration of test trials.

Bivariate correlations were calculated for Gross Locomotor ability and Communicative ability from the ASQ and the looking durations on test trials (see table 3b). No measures of locomotive ability and communicative ability were correlated with the look duration of test trials.

### **4.0 – Discussion**

The current study examined whether infants differentially discriminated changes from a bimodally displayed (happy face+voice) emotion to one where just the visual emotion was different, just the auditory emotion was different, or the visual+auditory emotion was different. Specifically, the current study examined whether the *relative* salience of either visual or auditory modality was greater than the other at a time in infant development during which emotion

processing of others is a critical aspect of emerging communication. It was predicted that when infants were habituated to bimodal happy emotional expressions, the look duration on V-only (i.e. fearful face + happy voice) would be greater than the look duration on A-only (i.e. happy face + fearful voice), but less than the look duration on AV (i.e. fearful face + fearful voice). In other words, it was expected that infants would show their strongest sensitivity to a change in both modalities and would show stronger sensitivity to a change in visual modality than to a change in auditory modality. This hypothesis was not supported by the results. The results showed consistent discrimination when visual emotion was changed, when auditory emotion was changed, and when both visual and auditory emotions were changed. However, the results did not show any evidence that infants were more sensitive to a particular change, but showed that they were equally sensitive to all types of changes.

As previously mentioned, while infants looked significantly longer at bimodal fearful display (AV) in comparison to bimodal happy display (Fam), there was no significant difference in look duration when comparing auditorily changed bimodal display (A-only) and visually changed bimodal display (V-only). As illustrated by Flom and Bahrick (2007), infants can discriminate emotions both bimodally and unimodally by the age of 7 months. They found that by the age of 7 months, discrimination was not superior in one condition over the other, which may explain the current results. Flom and Bahrick argued that because infants can discriminate emotion without modal restriction and their attention becomes flexible. This means that by the age of 7 months, infants do not need to rely on information from a particular modality or redundant information from two modalities (auditory and visual) at the same time. However, Flom and Bahrick (2007) did not compare infants' discrimination of a change in one modality while keeping the other constant - that is, their results cannot speak to the issue of competitive

advantage of one modality over another in emotion perception. Extending their findings, the results of the current study show that infants detect a change in auditorily and visually changed trials and audiovisually changed trial. Even in the presence of competitive information in one modality, infants were able to direct their attention to a change that occurred in another modality. It supports the notion that attention becomes more flexible by the age of 7 months, showing that infants discriminate emotions not only under conditions of unimodal and bimodal stimulation but also when auditory or visual emotion was changed in one modality even in the presence of competing emotion in another modality. Thus, it is possible that the relative salience of two modalities is not different.

However, the design of the current study limits this claim. Because the AV trial was always given at the end after two mismatched bimodal displays (i.e., A-only and V-only trial), the current study failed to provide evidence for whether infants discriminated bimodal change without depending on the single modality instead of both modalities at the same time. Given that the current study did not provide solid evidence that infants' discrimination of the bimodally changed displays was independent of unimodal discrimination, there is no clear evidence that one modality is relatively more salient than another.

In this study, it should be noted that infants showed enhanced attention across all test trials when V-only was given first, compared when A-only was given first. A recent study indicated that infants showed enhanced detection of fearful faces compared to happy faces even when the faces were visually obstructed from the view (Bayet, Quinn, Laboissiere, Caldara, Lee, & Pascalis, 2017). In this study, several pictures of faces with different levels of visual noise that obstructed visibility of the faces were used. When each of the pictures were presented with a picture that contained only visual noise (gray blobs), infants showed lower threshold to detect

fearful faces in comparison to the happy face. Specifically, infants in the study were able to detect fearful faces while they were not able to detect happy face with the same level of visual noise. This study highlighted infants' heightened attention and readiness to detect fearful faces. Considering fearful faces captivate infants' attention, it is possible that infants more readily detect a change in visual modality compared to a change in auditory modality, especially when fearful face was shown after the sequence of happy expressions. It was shown that when a fearful face was given prior to either happy or fearful voice, infants' attention to auditory information was increased regardless of the valence of vocal emotion (Otte et al., 2015). Thus, it may indicate that infants' detection of fear depends on visual information, suggesting the relative salience of visual modality is greater for the detection of fearful expressions. In terms of findings of the current study, enhanced attention on the fearful face may have continued to captivate infants' attention throughout the rest of trials. Thus, the order effect may have been due to the fact that visual change was easier to detect at least for the detection of fearful emotion and it heightened attention to fearful face may have carried over to the following test trials.

To explore individual differences in infants' abilities to discriminate, the association between infants' temperament and locomotion and their attention to both unimodal and bimodal change in emotional expressions were examined. In terms of the relations between intersensory emotional processing, temperament, and locomotion, the results of the study were not in line with previous studies. Martinos et al. (2012) found that infants with higher self-regulatory ability showed heightened attention to a fearful face, possibly because they exerted greater effort toward controlling attention when viewing fearful face. On the other hand, they found that negative emotionality was positively related to heightened attention to happy face.

In contrast, the results of this study showed the significant relations between surgency and attention to test trials. Specifically, the current study found that higher level of surgency (i.e., the expressivity of positive emotions) was related to heightened attention to a fearful face with happy voice (V-only), and decreased attention to happy face with fearful voice (A-only). Negative affectivity, on the other hand, showed no relations to any look durations on test trials. Considering the reciprocal relationship between infants' temperament and maternal behavior toward infants (Kiff, Lengua, & Zalewski, 2011), it is speculated that infants with high level of positive expressions may have experienced higher number of instance where they experienced positive emotions. The relations found in this study indicated that infants with higher level of positive expressions paid greater attention when visual modality was changed to less familiar emotion (i.e. fearful face) and paid less attention when auditory modality was changed to less familiar emotion (i.e. fearful voice).

#### **4.1 – Limitations**

There were several issues in the design and execution of this study that should be discussed as limitations. A primary limitation of this study is that the AV displays that were used in the study included static visual stimuli images. While the previous studies have shown that infants are capable of discriminating different emotions using static visual stimuli in both unimodal and bimodal contexts, this, in turn, may have resulted in ecologically invalid presentation of bimodal emotional expressions. Pointing that many previous studies have used static images to examine infant emotion processing rather than dynamic displays, Heck, Hock, White, Jubran, and Bhatt (2016) used dynamic emotion displays and found that infants showed enhanced attention to fear at earlier age than what previous study that used static images has found. Arguing that dynamic displays may be more ecologically valid and may results in

enhanced attention, Heck et al. (2016) raised the need to utilize dynamic emotional displays for ecological validity. Moreover, Sato, Kochiyama, Yoshikawa, Naito, and Matsumura (2004) showed that when infants' brain activity was measured for static facial expressions and dynamic facial expressions, infant showed greater brain activity when they watched dynamic facial expressions in comparison to when they watched static facial expressions. In line with this suggestion, the future studies should find a way to create coherent dynamic AV displays for further examination of the relative salience of different modalities.

A second limitation of this study is that the test order of test trials was semi-counterbalanced. Specifically, the test order included F trial to be always the first trial, and AV trial to be always the last trial. The order of the rest of test trials, A trial and V trial, was counterbalanced. Initially, because it was predicted that redundant stimulation of fearful bimodal display might be more potent than unimodally mismatched bimodal display, it was decided that AV trial would be given at the end of the procedure. Also, F trial was always shown as the first trial to be utilized as a posthabituation trial that function as a comparison to other test trials. This, in turn, created a limitation in the interpretation. In order to avoid this limitation, future efforts should include counterbalancing the order of all test trials.

## **4.2 – Conclusion**

The relative salience of different modalities in emotion discrimination was investigated using mismatches between visual and auditory modalities in the current study. The results of this study have extended the results of the previous studies in that, not only are infants capable of discriminating emotions unimodally and bimodally, but they can discriminate a change in visually mismatched and auditorily mismatched displays even when incongruent information is provided. However, the results of this study did not show any evidence that the differential

relative salience between visual and auditory modalities was present. It is suggested that the visual modality was relatively more potent in fear discrimination. However, this claim is only accurate for fearful emotion. When different negative emotions (i.e. anger; Grossmann et al., 2006) were used to examine infants' crossmodal perception of emotion, infants' attention on a mismatch between happy face and angry voice was greater than on a mismatch between angry face and happy voice. Grossmann et al. suggested that the attention on a mismatch using happy face was greater due to the expectation that happy face should match with happy voice. As portrayed by the comparison between the current study and Grossmann et al.'s study, type of emotion may have different effect on other emotion that is used as comparison. Thus, future studies should determine whether greater relative salience of visual modality is generalized to other types of emotion.

Finally, the relationship between individual differences (i.e. temperament and self-locomotion) and the relative salience of different modalities were explored. Although the results of this study suggest differential relationships between infants' temperament and self-locomotion, it may be too early to determine if the temperament measures predict the differential salience of modalities. Because the current study did not provide both environmental effect on infant and infant's influence on his or her environment, it is not clear to state that infants' own development influenced their bimodal information perception. Future studies, thus, should employ a way to examine the characteristics of infant's caregiver. Comparing caregiver characteristics, such as maternal sensitivity or emotion expressive style, will further clarify whether bidirectionality of infant-caregiver relationship influences infants' perception of bimodal information.



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Table 1.

*Habituation Descriptive Statistics*

	Mean	S.D.	Min	Max
Number of Habituation Trials	5.22	1.80	4	9
Average Time Habituation (seconds)	14.03	9.75	5.05	48.96
Average Time of First Two Habituation Trials	20.68	17.56	6.89	85.94

*Note. S.D. = Standard Deviation.*

Table 2a.

*Correlation Between Total Habituation Duration, Number of Habituation Trials, and Look Duration on Test Trials*

	Time to Habituation (Seconds)	Number of Habituation Trials	A-only	V-only	AV
Time to Habituation (Seconds)	-				
Number of Habituation Trials	.41	-			
A-only	-.02	.06	-		
V-only	-.21	-.36	-.42	-	
AV	.04	-.12	.55*	-.16	-

Note.  $n = 18$ .

\* $p < .05$ . \*\* $p < .01$

Table 2b.

*Correlation Between Total Habituation Duration, Number of Habituation Trials, IBQ Measures, and ASQ Measures*

	Time to Habituation	Number of Habituation Trials	IBQ: Surgency	IBQ: Neg. Affect.	IBQ: O/R	ASQ: Gross Motor	ASQ: Comm.
Time to Habituation (Seconds)	-						
Number of Habituation Trials	.41	-					
IBQ: Surgency	-.43	.06	-				
IBQ: Negative Affectivity	-.23	-.12	.15	-			
IBQ: Orientation/Regulation	-.12	-.05	.13	.07	-		
ASQ: Gross Motor	-.32	-.07	.63**	.51*	.004	-	
ASQ: Communication	-.30	.06	.60*	.36	-.08	.98**	-

Note.  $n = 18$ ; \*:  $p < .05$ ; \*\*:  $p < .01$

Table 3a.

*Correlation Between IBQ Measures and Look Duration on Test Trials*

	A-only	V-only	AV	IBQ: Surge ncy	IBQ: Neg Aff	IBQ: O/R
A-only	-					
V-only	-.42	-				
AV	.55*	-.16	-			
IBQ: Surgency	-.55*	.58*	-.31	-		
IBQ: Negative Affectivity	.001	.03	-.09	.15	-	
IBQ: Orientation/Regulation	.19	.35	.06	.13	.07	-

Note.  $n = 18$ .

\* $p < .05$ . \*\* $p < .01$

Table 3b.

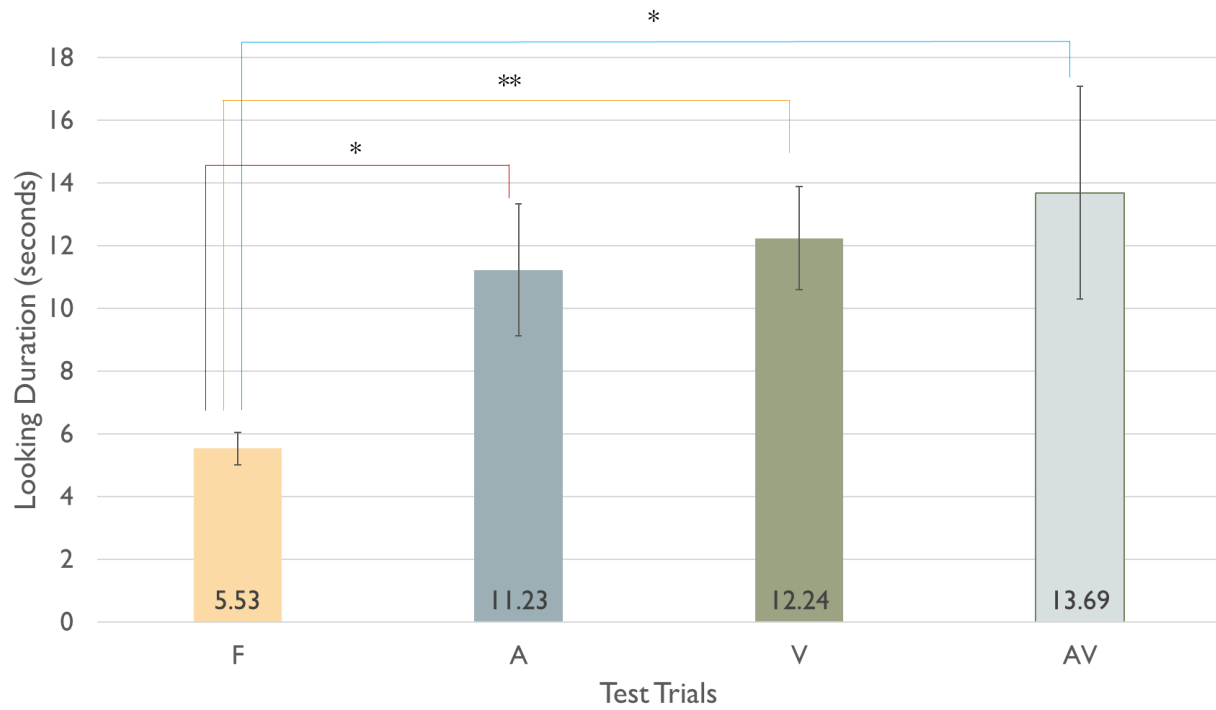
*Correlation Between ASQ Measures and Look Duration on Test Trials*

	ASQ Gross Motor	ASQ Communication <sup>a</sup>	A only	V only	AV
ASQ: Gross Motor	-				
ASQ: Communication <sup>a</sup>	.98**	-			
A only	-.24	-.22	-		
V only	.30	.25	-.42	-	
AV	.07	.03	.55*	-.16	-

Note.  $n = 18$ ; <sup>a</sup> $n = 16$

\* $p < .05$ . \*\* $p < .01$

Figure 1

*Looking Durations for Test Trials*

Note: \*:  $p < .05$ ; \*\*:  $p < .01$

## Appendix A Demographics Questionnaire



Infant # \_\_\_\_\_

Experiment # \_\_\_\_\_

### Infant Perception Laboratory

#### *Family Information Sheet*

(All information is strictly confidential)

Infant's Birthdate: \_\_\_\_\_ Mother's Age: \_\_\_\_\_ Father's Age: \_\_\_\_\_

Mother's Occupation: \_\_\_\_\_ Father's Occupation: \_\_\_\_\_

Mother's Education:    High School    Partial College    College    Master's    Ph.D.

Father's Education:    High School    Partial College    College    Master's    Ph.D.

 Annual Family Income:    \$10,000-\$20,000    \$20,000-\$35,000    \$35,000-\$50,000  
    \$50,000-\$65,000    \$65,000-\$80,000    \$80,000-\$95,000    > \$95,000

Marital Status:    Married    Separated    Divorced    Unmarried/Single    Widowed

Mother's Race:    White/Caucasian    African American    Hispanic    Asian    Native American

Other \_\_\_\_\_

Father's Race:    White/Caucasian    African American    Hispanic    Asian    Native American

Other \_\_\_\_\_

 Was your infant:    Full Term (38–42 weeks)    Premature ( $\leq$  37 weeks)    Postmature  
 (>42 weeks)

Infant's Birthweight: \_\_\_\_\_ lbs \_\_\_\_\_ ozs

Has your infant had any medical problems? Yes No Please List: \_\_\_\_\_

Please list the birth date and gender of any older children:

\_\_\_\_\_ M F \_\_\_\_\_ M F

\_\_\_\_\_ M F \_\_\_\_\_ M F

What is the primary language spoken in your home? \_\_\_\_\_

Please list any other languages that are spoken in your home: \_\_\_\_\_

Does your infant watch any T.V.? Yes No Please list: \_\_\_\_\_

Has any child in the family been suspected of a developmental delay/diagnosis? Yes No

If yes, please describe: \_\_\_\_\_

How did you find out about our study?    Letter    Brochure    Friend    Lecture



## Appendix B

## Informed Consent Form

**VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY****Informed Consent for Participants  
in Research Projects Involving Human Subjects****Title of Project:** Perception of Auditory and Visual Aspect of Emotion

<b>Investigator(s):</b>	<u>Dr. Robin Panneton</u>	<u>cooper@vt.edu/540-231-5938</u>
	Name	E-mail / Phone number
	<u>Lawrence N. Kim</u>	<u>lrnkim@vt.edu/404-451-8482</u>
	Name	E-mail / Phone number

**I. Purpose of this Research Project**

The purpose of this project is to investigate infants' perception of emotional expressions. Your infant will get to see and hear one emotion expression from an adult female (e.g., a smiling woman with a happy voice or fearful woman with a fearful voice). After becoming familiar with this emotion display, we will systematically change the facial expression, the vocal expression, or both to see which aspects of emotion your infant seems most sensitive to. Specifically, we are interested in how infants integrate visual and auditory information together as one emotion, and whether infants use visual or auditory information more depending on whether the emotion is positive (happy) compared to negative (fear). The study results will be used for partial fulfillment of the master of science degree in psychology (for Lawrence Kim), and for publication in a developmental journal.

**II. Procedures**

Following the completion of questionnaires, your infant will be tested for approximately 15 minutes, provided that he/she is awake, alert, and quiet. If your infant cries, we will terminate testing and there will be no penalty to you. Your infant will sit in a highchair, and face a TV monitor. If your infant refuses to sit in a highchair, then your infant will sit on your lap, and you will wear a black-tinted glasses and headphones that will play soft music. The purpose of the glasses and headphones are to keep you unaware of the specific sounds and facial expressions that your infant is seeing and hearing so that your reactions will not influence the infants' reactions to the critical change in emotional expressions. We ask that you minimize your interactions with your infant during the experiment unless the infant becomes upset.

Once the experiment begins, your infant will see a short movie clip of a baby laughing which will play in the center of the screen, and when your infant looks at the baby, it disappears, and then a display of a woman will be presented as she portrays happy or fearful emotions (her facial expression and the voice track will both match the same intended emotion). The display will continue to play as long as your infant attends to it. When your infant looks away from this

display for at least 1.5 seconds, it will disappear, the laughing baby will reappear, and we will repeat this entire sequence. Once your infant has habituated to the display (that is, they lose their interest), he/she will then see four different displays that (1) portray the same emotion as before, (2) portray the same vocal emotion but a different facial emotion, (3) portray the same facial emotion, but a different vocal emotion, and (4) portray a different facial and vocal emotion. Each display will continue to play as long as your infant looks at the screen. If your infant cries for any reason at any point during the experiment, testing will be discontinued.

We will create a digital recording of your infant during the session, so that we can watch the baby from an adjoining room in order to code his/her attention to the computer screen. Also, this digital recording will be used later to recode your infant's behavior for reliability estimation. However, no identifying information about your baby will appear on these digital recordings.

### **III. Risks**

There are no apparent risks to your infant or to yourself for participation in this study. Prior to the testing of each subject, sound levels for all auditory stimuli will be kept at normal conversational level (70~72 dB) and the parent's headphones will be tested.

### **IV. Benefits**

While there are no direct benefits to the participants in this study, your infant's and your participation will help us understand further how infants process and integrate bimodal emotional information.

### **V. Extent of Anonymity and Confidentiality**

All of the information gathered in this study will be kept confidential and the results will not be released without parental consent. The information that you and your infant provide will be identified by a participant number only, not a name. Your informed consent will be kept separate from all other information. The results of this study may be presented at scientific meetings, and/or published in a scientific journal. We will send all participants a summary of the outcome of this study in a local newsletter, published bi-annually by our research lab. All digital movies of infants in this study will be destroyed after 5 years.

The Virginia Tech (VT) Institutional Review Board (IRB) may view the study's data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

### **VI. Compensation**

At the end of this study, you will be compensated with \$10 for your participation.

## VII. Freedom to Withdraw

It is important for you to know that you are free to withdraw from this study at any time without penalty. You are free to not answer any questions that you choose or respond to what is being asked of you without penalty. Should you withdraw or otherwise discontinue participation, you will be compensated for the portion of the project completed in accordance with the Compensation section of this document.

## VIII. Questions or Concerns

Should you have any questions about this study, you may contact one of the research investigators whose contact information is included at the beginning of this document.

Should you have any questions or concerns about the study's conduct or your rights as a research subject, or need to report a research-related injury or event, you may contact the VT IRB Chair, Dr. David M. Moore at [moored@vt.edu](mailto:moored@vt.edu) or (540) 231-4991.

## IX. Subject's Consent

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

\_\_\_\_\_ Date \_\_\_\_\_  
Parent's signature

\_\_\_\_\_  
Parent's printed name

\_\_\_\_\_  
Name of infant

I would like to be contacted by phone regarding future studies:      Yes                  No

## Appendix C

## Infant Behavior Questionnaire – Revised Very Short Form

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 Maria A. Gartstein  
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### Infant Behavior Questionnaire – Revised Very Short Form

Subject No. \_\_\_\_\_ Date of Baby's Birth \_\_\_\_\_ month. \_\_\_\_\_ day \_\_\_\_\_ year  
 Today's Date \_\_\_\_\_ Age of Child \_\_\_\_\_ mos. \_\_\_\_\_ weeks  
 Sex of Child \_\_\_\_\_

**INSTRUCTIONS:**

Please read carefully before starting:

As you read each description of the baby's behavior below, please indicate how often the baby did this during the LAST WEEK (the past seven days) by circling one of the numbers in the left column. These numbers indicate how often you observed the behavior described during the last week.

<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>NA</b>
<b>Never</b>	<b>Very Rarely</b>	<b>Less Than Half the Time</b>	<b>About Half the Time</b>	<b>More Than Half the Time</b>	<b>Almost Always</b>	<b>Always</b>	<b>Does Not Apply</b>

The "Does Not Apply" (X) column is used when you did not see the baby in the situation described during the last week. For example, if the situation mentions the baby having to wait for food or liquids and there was no time during the last week when the baby had to wait, circle the (X) column. "Does Not Apply" is different from "Never" (1). "Never" is used when you saw the baby in the situation but the baby never engaged in the behavior listed during the last week. For example, if the baby did have to wait for food or liquids at least once but never cried loudly while waiting, circle the (1) column.

Please be sure to circle a number for every item.

**1.** When being dressed or undressed during the last week, how often did the baby squirm and/or try to roll away?

1    2    3    4    5    6    7    NA

**2.** When tossed around playfully how often did the baby laugh?

1    2    3    4    5    6    7    NA

**3.** When tired, how often did your baby show distress?

1    2    3    4    5    6    7    NA

**4.** When introduced to an unfamiliar adult, how often did the baby cling to a parent?

1    2    3    4    5    6    7    NA

**5.** How often during the last week did the baby enjoy being read to?

1    2    3    4    5    6    7    NA

**6.** How often during the last week did the baby play with one toy or object for 5-10 minutes?

1    2    3    4    5    6    7    NA

**7.** How often during the week did your baby move quickly toward new objects?

1    2    3    4    5    6    7    NA

**8.** When put into the bath water, how often did the baby laugh?

1    2    3    4    5    6    7    NA

**9.** When it was time for bed or a nap and your baby did not want to go, how often did s/he whimper or sob?

1    2    3    4    5    6    7    NA

**10.** After sleeping, how often did the baby cry if someone doesn't come within a few minutes?

1    2    3    4    5    6    7    NA

**11.** In the last week, while being fed in your lap, how often did the baby seem eager to get away as soon as the feeding was over?

1      2      3      4      5      6      7      NA

**12.** When singing or talking to your baby, how often did s/he soothe immediately?

1      2      3      4      5      6      7      NA

**13.** When placed on his/her back, how often did the baby squirm and/or turn body?

1      2      3      4      5      6      7      NA

**14.** During a peekaboo game, how often did the baby laugh?

1      2      3      4      5      6      7      NA

**15.** How often does the infant look up from playing when the telephone rings?

1      2      3      4      5      6      7      NA

**16.** How often did the baby seem angry (crying and fussing) when you left her/him in the crib?

1      2      3      4      5      6      7      NA

**17.** How often during the last week did the baby startle at a sudden change in body position (e.g., when moved suddenly)?

1      2      3      4      5      6      7      NA

**18.** How often during the last week did the baby enjoy hearing the sound of words, as in nursery rhymes?

1      2      3      4      5      6      7      NA

**19.** How often during the last week did the baby look at pictures in books and/or magazines for 5 minutes or longer at a time?

1      2      3      4      5      6      7      NA

**20.** When visiting a new place, how often did your baby get excited about exploring new surroundings?

1      2      3      4      5      6      7      NA

**21.** How often during the last week did the baby smile or laugh when given a toy?

1      2      3      4      5      6      7      NA

**22.** At the end of an exciting day, how often did your baby become tearful?

1    2    3    4    5    6    7    NA

**23.** How often during the last week did the baby protest being placed in a confining place (infant seat, play pen, car seat, etc.)?

1    2    3    4    5    6    7    NA

**24.** When being held, in the last week, did your baby seem to enjoy him/herself?

1    2    3    4    5    6    7    NA

**25.** When showing the baby something to look at, how often did s/he soothe immediately?

1    2    3    4    5    6    7    NA

**26.** When hair was washed, how often did the baby vocalize?

1    2    3    4    5    6    7    NA

**27.** How often did your baby notice the sound of an airplane passing overhead?

1    2    3    4    5    6    7    NA

**28.** When introduced to an unfamiliar adult, how often did the baby refuse to go to the unfamiliar person?

1    2    3    4    5    6    7    NA

**29.** When you were busy with another activity, and your baby was not able to get your attention, how often did s/he cry?

1    2    3    4    5    6    7    NA

**30.** How often during the last week did the baby enjoy gentle rhythmic activities, such as rocking or swaying?

1    2    3    4    5    6    7    NA

**31.** How often during the last week did the baby stare at a mobile, crib bumper or picture for 5 minutes or longer?

1    2    3    4    5    6    7    NA

**32.** When the baby wanted something, how often did s/he become upset when s/he could

not get what s/he wanted?

1    2    3    4    5    6    7    NA

**33.** When in the presence of several unfamiliar adults, how often did the baby cling to a parent?

1    2    3    4    5    6    7    NA

**34.** When rocked or hugged, in the last week, did your baby seem to enjoy him/herself?

1    2    3    4    5    6    7    NA

**35.** When patting or gently rubbing some part of the baby's body, how often did s/he soothe immediately?

1    2    3    4    5    6    7    NA

**36.** How often did your baby make talking sounds when riding in a car?

1    2    3    4    5    6    7    NA

**37.** When placed in an infant seat or car seat, how often did the baby squirm and turn body?

1    2    3    4    5    6    7    NA



## Appendix D

## Ages and Stages Questionnaire – 3



## 8 Month Questionnaire

7 months 0 days  
through 8 months 30 days

On the following pages are questions about activities babies may do. Your baby may have already done some of the activities described here, and there may be some your baby has not begun doing yet. For each item, please fill in the circle that indicates whether your baby is doing the activity regularly, sometimes, or not yet.

**Important Points to Remember:**

- Try each activity with your baby before marking a response.
- Make completing this questionnaire a game that is fun for you and your baby.
- Make sure your baby is rested and fed.
- Please return this questionnaire by \_\_\_\_\_.

**Notes:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**COMMUNICATION**





- |   | YES                   | SOMETIMES             | NOT YET               |     |
|---|-----------------------|-----------------------|-----------------------|-----|
| 1. If you call to your baby when you are out of sight, does she look in the direction of your voice?                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 2. When a loud noise occurs, does your baby turn to see where the sound came from?                                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 3. If you copy the sounds your baby makes, does your baby repeat the same sounds back to you?                           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 4. Does your baby make sounds like "da," "ga," "ka," and "ba"?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 5. Does your baby respond to the tone of your voice and stop his activity at least briefly when you say "no-no" to him? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 6. Does your baby make two similar sounds like "ba-ba," "da-da," or "ga-ga"? (The sounds do not need to mean anything.) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |

COMMUNICATION TOTAL \_\_\_

**GROSS MOTOR**

- |   | YES                   | SOMETIMES             | NOT YET               |     |
|---|-----------------------|-----------------------|-----------------------|-----|
| 1. When you put your baby on the floor, does she lean on her hands while sitting? (If she already sits up straight without leaning on her hands, mark "yes" for this item.)  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 2. Does your baby roll from his back to his tummy, getting both arms out from under him?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |

**GROSS MOTOR** (continued)

- |  | YES                   | SOMETIMES             | NOT YET               |     |
|--|-----------------------|-----------------------|-----------------------|-----|
| 3. Does your baby get into a crawling position by getting up on her hands and knees?    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 4. If you hold both hands just to balance your baby, does he support his own weight while standing?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 5. When sitting on the floor, does your baby sit up straight for several minutes without using her hands for support?                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |
| 6. When you stand your baby next to furniture or the crib rail, does he hold on without leaning his chest against the furniture for support?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | ___ |

GROSS MOTOR TOTAL \_\_\_

\*If Gross Motor Item 5 is marked "yes" or "sometimes," mark Gross Motor Item 1 "yes."



## 10 Month Questionnaire

9 months 0 days  
through 10 months 30 days

On the following pages are questions about activities babies may do. Your baby may have already done some of the activities described here, and there may be some your baby has not begun doing yet. For each item, please fill in the circle that indicates whether your baby is doing the activity regularly, sometimes, or not yet.

### COMMUNICATION



- |  | YES                   | SOMETIMES             | NOT YET               |   |
|--|-----------------------|-----------------------|-----------------------|---|
| 1. Does your baby make sounds like "da," "ga," "ka," and "ba"?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 2. If you copy the sounds your baby makes, does your baby repeat the same sounds back to you?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 3. Does your baby make two similar sounds like "ba-ba," "da-da," or "ga-ga"? ( <i>The sounds do not need to mean anything.</i> )   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 4. If you ask your baby to, does he play at least one nursery game even if you don't show him the activity yourself (such as "bye-bye," "Peeka-boo," "clap your hands," "So Big")? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 5. Does your baby follow one simple command, such as "Come here," "Give it to me," or "Put it back," without your using gestures?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 6. Does your baby say three words, such as "Mama," "Dada," and "Baba"? ( <i>A "word" is a sound or sounds your baby says consistently to mean someone or something.</i> )          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |

COMMUNICATION TOTAL —

### GROSS MOTOR

- |   | YES                   | SOMETIMES             | NOT YET               |   |
|---|-----------------------|-----------------------|-----------------------|---|
| 1. If you hold both hands just to balance your baby, does she support her own weight while standing?                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 2. When sitting on the floor, does your baby sit up straight for several minutes without using his hands for support?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |

### GROSS MOTOR (continued)

- |   | YES                   | SOMETIMES             | NOT YET               |   |
|---|-----------------------|-----------------------|-----------------------|---|
| 3. When you stand your baby next to furniture or the crib rail, does she hold on without leaning her chest against the furniture for support?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 4. While holding onto furniture, does your baby bend down and pick up a toy from the floor and then return to a standing position?             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 5. While holding onto furniture, does your baby lower himself with control (without falling or flopping down)?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 6. Does your baby walk beside furniture while holding on with only one hand?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |

GROSS MOTOR TOTAL —



## 12 Month Questionnaire

11 months 0 days  
through 12 months 30 days


On the following pages are questions about activities babies may do. Your baby may have already done some of the activities described here, and there may be some your baby has not begun doing yet. For each item, please fill in the circle that indicates whether your baby is doing the activity regularly, sometimes, or not yet.

### COMMUNICATION



- |   | YES                   | SOMETIMES             | NOT YET               |   |
|---|-----------------------|-----------------------|-----------------------|---|
| 1. Does your baby make two similar sounds, such as "ba-ba," "da-da," or "ga-ga"? (The sounds do not need to mean anything.)   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 2. If you ask your baby to, does he play at least one nursery game even if you don't show him the activity yourself (such as "bye-bye," "Peek-a-boo," "clap your hands," "So Big")? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 3. Does your baby follow one simple command, such as "Come here," "Give it to me," or "Put it back," without your using gestures?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 4. Does your baby say three words, such as "Mama," "Dada," and "Baba"? (A "word" is a sound or sounds your baby says consistently to mean someone or something.)                    | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 5. When you ask, "Where is the ball (hat, shoe, etc.)?" does your baby look at the object? (Make sure the object is present. Mark "yes" if she knows one object.)                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 6. When your baby wants something, does he tell you by pointing to it?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |

COMMUNICATION TOTAL —

### GROSS MOTOR

- |  | YES                   | SOMETIMES             | NOT YET               |   |
|--|-----------------------|-----------------------|-----------------------|---|
| 1. While holding onto furniture, does your baby bend down and pick up a toy from the floor and then return to a standing position?  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 2. While holding onto furniture, does your baby lower herself with control (without falling or flopping down)?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 3. Does your baby walk beside furniture while holding on with only one hand?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |

### GROSS MOTOR (continued)

- |  | YES                   | SOMETIMES             | NOT YET               |   |
|--|-----------------------|-----------------------|-----------------------|---|
| 4. If you hold both hands just to balance your baby, does he take several steps without tripping or falling? (If your baby already walks alone, mark "yes" for this item.)  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 5. When you hold one hand just to balance your baby, does she take several steps forward? (If your baby already walks alone, mark "yes" for this item.)                     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |
| 6. Does your baby stand up in the middle of the floor by himself and take several steps forward?   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | — |

GROSS MOTOR TOTAL —



## 14 Month Questionnaire

13 months 0 days  
through 14 months 30 days

On the following pages are questions about activities babies may do. Your baby may have already done some of the activities described here, and there may be some your baby has not begun doing yet. For each item, please fill in the circle that indicates whether your baby is doing the activity regularly, sometimes, or not yet.

### Important Points to Remember:

- Try each activity with your baby before marking a response.
- Make completing this questionnaire a game that is fun for you and your baby.
- Make sure your baby is rested and fed.
- Please return this questionnaire by \_\_\_\_\_.

### Notes:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### COMMUNICATION

	YES	SOMETIMES	NOT YET	
1. Does your baby say three words, such as "Mama," "Dada," and "Baba"? (A "word" is a sound or sounds your baby says consistently to mean someone or something.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
2. When your baby wants something, does she tell you by <i>pointing</i> to it?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
3. Does your baby shake his head when he means "no" or "yes"?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
4. Does your baby point to, pat, or try to pick up pictures in a book?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
5. Does your baby say four or more words in addition to "Mama" and "Dada"?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
6. When you ask her to, does your baby go into another room to find a familiar toy or object? (You might ask, "Where is your ball?" or say, "Bring me your coat," or "Go get your blanket.")	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___

COMMUNICATION TOTAL \_\_\_

### GROSS MOTOR

	YES	SOMETIMES	NOT YET	
1. If you hold both hands just to balance your baby, does he take several steps without tripping or falling? (If your baby already walks alone, mark "yes" for this item.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
2. When you hold <i>one hand</i> just to balance your baby, does she take several steps forward? (If your baby already walks alone, mark "yes" for this item.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___



### GROSS MOTOR (continued)

	YES	SOMETIMES	NOT YET	
3. Does your baby stand up in the middle of the floor by himself and take several steps forward?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
4. Does your baby climb onto furniture or other large objects, such as large climbing blocks?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
5. Does your baby bend over or squat to pick up an object from the floor and then stand up again without any support?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
6. Does your baby move around by walking, rather than by crawling on his hands and knees?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___

GROSS MOTOR TOTAL \_\_\_



## 16 Month Questionnaire

15 months 0 days  
through 16 months 30 days

On the following pages are questions about activities children may do. Your child may have already done some of the activities described here, and there may be some your child has not begun doing yet. For each item, please fill in the circle that indicates whether your child is doing the activity regularly, sometimes, or not yet.

### Important Points to Remember:

- Try each activity with your child before marking a response.
- Make completing this questionnaire a game that is fun for you and your child.
- Make sure your child is rested and fed.
- Please return this questionnaire by \_\_\_\_\_.

### Notes:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### COMMUNICATION

	YES	SOMETIMES	NOT YET	
1. Does your child point to, pat, or try to pick up pictures in a book?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
2. Does your child say four or more words in addition to "Mama" and "Dada"?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
3. When your child wants something, does she tell you by <i>pointing</i> to it?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
4. When you ask your child to, does he go into another room to find a familiar toy or object? (You might ask, "Where is your ball?" or say, "Bring me your coat," or "Go get your blanket.")	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
5. Does your child imitate a two-word sentence? For example, when you say a two-word phrase, such as "Mama eat," "Daddy play," "Go home," or "What's this?" does your child say both words back to you? (Mark "yes" even if her words are difficult to understand.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
6. Does your child say eight or more words in addition to "Mama" and "Dada"?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
				COMMUNICATION TOTAL ___

### GROSS MOTOR

	YES	SOMETIMES	NOT YET	
1. Does your child stand up in the middle of the floor by himself and take several steps forward?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
2. Does your child climb onto furniture or other large objects, such as large climbing blocks?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
3. Does your child bend over or squat to pick up an object from the floor and then stand up again without any support?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___

### GROSS MOTOR (continued)

	YES	SOMETIMES	NOT YET	
4. Does your child move around by walking, rather than crawling on her hands and knees?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
5. Does your child walk well and seldom fall?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
6. Does your child climb on an object such as a chair to reach something he wants (for example, to get a toy on a counter or to "help" you in the kitchen)?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	___
				GROSS MOTOR TOTAL ___

## Appendix E

### Phrases Used in Events

#### Happy:

We laughed and clapped and danced until the sun left the sky, and the moon rose above. It was beautiful night, full of magic! The air smelled like cookies baking in the oven, and all of our tummies were pleased. Smiles were on every face! Everything was perfect. It was the best night of my life. (56 words)

#### Fear:

The horrible animal rushed toward me, foaming at the mouth. The wolf ducked down, and then it leaped up, snapping its huge jaws at me. I gasped and twisted around, but it was on me, trying to pull me out. Even if the wolf was fake, it was the creepiest thing I had ever seen. (55 words)



## Appendix F

## Emotional Facial Expressions Used in Events



Fear



Happy



Fear



Happy

Visual components of the emotion displays used in the experiments. Happy and Fearful facial expressions of two models (model #01 and model #03) were chosen from the NimStim dataset.