Bidirectional Influence of Emotion Processing on Language Development in Infancy: Evidence from Eye-tracking Mothers and Infants

Alison Rae Heck

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in
Psychology

Committee Members:

Robin K. Panneton, Chair
Julie C. Dunsmore
Susan W. White
Kirby Deater-Deckard

May 12, 2015

Blacksburg, Virginia

Keywords: emotion processing, language processing, infancy, eye-tracking, parental sensitivity, referential learning

Bidirectional Influence of Emotion Processing on Language Development in Infancy: Evidence from Eye-tracking Mothers and Infants

Alison Rae Heck

ABSTRACT

The primary goal of this study was to examine how infants' language and emotion development intersect around the end of the first year. Specifically, is learning enhanced when a speaker is happy vs. neutral? Eighteen 12-month-old infants were familiarized and tested on four word-object associations that varied in bimodal emotion (happy vs. neutral), which were presented on a Tobii© T60 eye-tracker. Familiarization trials comprised of actresses looking towards and labeling a target object while ignoring a non-target distractor object on the opposite side of the screen. It was expected that infants would demonstrate better learning of word-object associations during the test trials when the speaker was happy. This hypothesis was partially supported, in that infants demonstrated a novelty preference for the novel non-target object compared to the familiar target object in the happy test trials only. However, no difference in attention was seen in happy test trials with the familiar target object and a familiar non-target object or for either of the neutral test trials. A second goal of this study was to examine infant-parent correspondence in emotion processing. Both infants and parents were presented with a series of emotion pairs on the eye-tracker, and the correlations between their gaze patterns were examined. In general, infants and parents had little to no correspondence in first look tendencies or overall fixation duration to either face in the pair. They also fixated on different areas of the face (infants on mouth region, parents on eye region). Finally, parental sensitivity was examined using a free-play interaction task. Parents' sensitivity was analyzed with respect to measures of infants learning during the language task as well as other infant characteristics (e.g.

temperament, vocabulary). Overall, these findings add to the relatively limited research examining the intersection of language and socioemotional development in infancy.

Table of Contents

List of Figures

List of Tables

1.0 – Introduction

Language development and socioemotional development are rarely examined in conjunction with one another during infancy. However, there is evidence that what happens in one domain affects development in the other. Both language and socioemotional skills share two key requirements for successful development: the need for high parental sensitivity and, within it, contingent responding. Language and socioemotional development have the potential to be negatively affected by low parental sensitivity and a lack of contingent responding, as can be seen when examining the literature on maternal depression and its effects on infants (e.g., Kaplan, Burgess, Sliter, & Moreno, 2009). Consistent and timely responses by caregivers provide infants with a wealth of information, particularly with regards to labeling novel objects and gleaning socioemotional cues from the environment. This study examined how these socioemotional cues (e.g. eye gaze with neutral or positively-valenced facial + vocal emotion expression) affect associative word-object learning in 12-month-old infants. Additionally, correlations between parent and infant gaze patterns towards different emotion expressions (e.g. happy, fear, sad) were tested using a novel eye-tracking task that had the parent and infant separately viewing the same sequence of emotion pairs. Finally, the relationship between maternal depression and anxiety symptomatology and infants' word-object learning and emotion gaze patterns was explored.

The following literature review first argues for the importance of the parent-infant relationship, especially with respect to the role of maternal sensitivity, in infants' socioemotional and language development. Maternal sensitivity will be discussed more in terms of how it encompasses behaviors such as contingent responding, social referencing, and joint attention. The next sections review findings with regards to behavioral responses to different modalities of emotion expressions (e.g. unimodal vocal-only, unimodal visual-only, bimodal audiovisual) for both infants and adults. Due to the secondary interest in maternal depression, the differing behavior of infants of depressed mothers and depressed individuals will be discussed. Next, the literature examining both language and socioemotional development together in some fashion will be discussed. Finally, an argument for the importance of examining these two domains as bidirectionally affecting one another rather than as separate but co-occurring skills will be presented.

1.1 - **Parent-Infant Communication**

John Locke eloquently described the importance of the mother-infant dyad's vocal "communion" with regards to the bidirectional ability that successful communication has in conveying information from the mother to the infant and from the infant to the mother (Locke, 2001). In infancy, it is not necessarily the linguistic aspect that is so important in vocal communications, but rather the act of attracting and maintaining the other's attention. Therefore, it is not the *words* that the infant is attracted to, but the *mother* saying the words. Mother and infant are trying to connect with one another not only through mutual gaze, but also through mutual vocal communication. The importance of maternal sensitivity, and within it, contingent responding, is especially relevant to this point. The latent inhibition/learned irrelevance hypothesis will be discussed as it connects a lack of sensitivity with the poor associative learning abilities shown by infants of depressed mothers.

Maternal sensitivity. Much of the research on maternal sensitivity has been couched within the framework of attachment theory (Ainsworth & Bowlby, 1991). Attachment theory, introduced to the field by John Bowlby and Mary Ainsworth, encompasses many behaviors necessary for fostering a high-quality mother-child relationship. Although attachment theory is often used to explain mother-infant relationships, of interest here are the actual behaviors used to measure attachment rather than the attachment relationship itself. One of the most important components of attachment is maternal sensitivity (Bretherton, 1992; Smith & Pederson, 1988). The definition of maternal sensitivity that Smith and Pederson (1988) propose focuses on a mother's awareness of her infants' behavioral cues, and then on her ability to both interpret and respond to these cues appropriately and promptly. Maternal sensitivity includes behaviors such as contingent responding, joint attention, and mutual regulation. High maternal sensitivity requires consistent responding to an infant's signals and responding in an appropriate manner to the infant's current capabilities (Bigelow et al., 2010). Vocal contingency, in which the mother vocally responds to her infant's bids for attention, was found to be the best predictor of secure attachment in a longitudinal study by Bigelow et al. (2010). Joint attention, in which mother and infant actively co-attend to a third party (e.g. an object or an event), has also been found to be linked to attachment security in early childhood (Naber et al., 2007). Typically-developing toddlers who engaged in more joint attention with their mothers were the ones who tended to be classified as securely attached, in contrast to those who displayed less joint attention (Naber et al., 2007).

Low maternal sensitivity is one potential explanation for why maternal depression has a negative effect on infants' socioemotional and language development. Lower maternal sensitivity in depressed mothers compared to non-depressed mothers has been found in multiple studies (e.g. Campbell, Cohn, & Meyers, 1995; Kaplan et al., 2009). One experimental simulation of the non-contingent responding often seen in depressed mothers is the still-face paradigm (Cohn & Tronick, 1983), which can be used as a predictor of mother-infant attachment. The still-face paradigm has been used to simulate depression, as mothers are told to imagine how they feel when they are depressed or tired. The mothers are instructed to speak with a flat and monotone voice to their infant and also to limit their facial expressions and body movement both in terms of their own movement as well as how often they touch their infant. Mothers are also instructed to gaze directly at their infant during the still-face period (Cohn & Tronick, 1983). Typically, infants respond to the still-face by alternating between protesting (e.g. crying, arching back), looking away from the mother, and looking at the mother with a wary facial expression. Infants in the still-face condition also show instances of "brief positive" behavior, in which they smile briefly at their mothers and then gaze avert (Cohn & Tronick, 1983). Interestingly, Field et al. (2007) found that depressed mothers' infants were less distressed and less interactive than infants of non-depressed mothers during the still-face condition, which they interpreted as a consequence of those infants' prior exposure to flat affect and non-contingent responding.

Another paradigm illustrating the differences in infants of depressed vs. non-depressed mothers is the non-contingent maternal behavior paradigm. In this procedure, Field et al. (2005) examined three different interactions between mother and infant using two TV monitors. In the contingent condition, mothers and infants viewed one another on TV monitors in real time. In the non-contingent condition, the infant was shown a replay of the mother from the contingent interaction on the TV monitor. Finally, the third condition was another live, contingent interaction between mother and infant on the two TV monitors. Field et al. (2005) found that compared to infants of non-depressed mothers, infants of depressed mothers showed fewer negative behavior changes, such as an increase in frowning and decrease in smiling, during the non-contingent condition. They argued that this was possibly because infants of depressed mothers are used to inconsistent responding, whereas for the non-depressed mothers' infants, non-contingent responding violates their expectations based on previous interactions. Additionally, non-depressed mothers smiled less during the second contingent interaction, whereas depressed mothers smiled less overall during both contingent interactions compared to the non-depressed mothers. Therefore, it may be that non-depressed mothers are sensitive to the negative changes in their infants' behaviors, and thus respond with less positive behavior themselves. On the other hand, depressed mothers may not pick up on their infants' cues; plus, these infants showed fewer negative behavioral changes overall in response to the non-contingent condition.

Interestingly, Field, Diego, Hernandez-Reif, Schanberg, and Kuhn (2003) found that when depressed mothers are shown to have a "good interaction" style as opposed to intrusive or withdrawn styles (i.e., typically how depressed mothers' interactive styles are categorized), their infants more closely matched non-depressed mothers' infants on the Brazelton Neonatal Behavioral Assessment Scale (BNBAS). The BNBAS (Als, Tronick, Lester, & Brazelton, 1977) is a scale used to evaluate newborn infants' neurological responsivity in various domains (e.g. responsiveness to visual and auditory stimuli) and behaviors such as the startle response, activity, and irritability. The BNBAS is also often used to assess whether or not an infant is considered "at risk." Compared to depressed mothers who demonstrate a withdrawn interactive style, depressed mothers with a good interaction style had infants who scored higher on the habituation, orientation, motor, and range of state scales, and also had fewer depressive symptoms (Field et al., 2003). Therefore, some of the negative effects typically seen in depressed mothers' interactions with their infants are attenuated when the interactions are of a higher quality.

In addition to maternal sensitivity, there are also a number of other elements related to parent-infant communication that are important for both language and socioemotional development. Young, Merin, Rogers, and Ozonoff (2009) found that 6-month-old infants who looked longer at the mouth of their mother during a live mother-infant interaction task on an eye-tracker scored higher on the expressive language scales at 24 months. This was true for both of their measures of expressive language: the Mullen Scales of Early Learning and the MacArthur Communicative Development Inventory (MCDI; Fenson et al., 1993). However, this relationship was only true for expressive language. There was no relationship between time spent on the mouth and receptive language scores. Additionally, infants who looked more at the mouth scored better on the socialization domain scale on the Vineland. These findings point to the importance of examining not only infants' social referencing skills to their mothers, but also where infants are looking on their mothers' faces. The following sections will provide evidence for differences in processing across sensory modalities (e.g. auditory vs. visual vs. audiovisual) by emotion type, which is particularly important for the development of both language and socioemotional skills.

1.2 - Infants' Responses to Vocal-Only Emotion Cues

Infants' abilities to modify their behavior in response to vocal-only emotion cues do not develop until the latter half of the first postnatal year, which can be seen when examining social referencing paradigms. In one particular example, mothers were asked to provide either vocal-only or visual-only emotion cues to their 12-month-old infants (Mumme, Fernald, & Herrera, 1996). Infants who heard a fearful vocal expression from their mothers approached a target toy less often, demonstrated more negative affect, and referred back to their mothers more frequently compared to infants who had heard either a neutral or happy vocal expression. In contrast, this effect of emotion expression was not found in the visual-only condition. Mumme et al. (1996)

interpreted this discrepancy in terms of the diminished signal value of a fearful facial expression alone compared to an auditory expression of fear.

Another specific area of research into vocal cues of emotion includes studies examining infant-directed speech (IDS). Although IDS is not solely unimodal, it is often studied as though it pertains only to spoken language. There are several auditory characteristics of IDS that facilitate infants' attention (e.g. short utterances, higher and more variable pitch, slow tempo; Cooper & Aslin, 1990; Fernald & Kuhl, 1987). IDS is also typically characterized as having exaggerated prosody (i.e., highly modulated suprasegmental pitch contours), leading IDS to be highly salient to most infants. Newborn and 1-month-old infants (Cooper & Aslin, 1990) as well as 4-month-old infants (Cooper, Abraham, Berman, & Staska, 1997; Kaplan, Goldstein, Huckeby, & Cooper, 1995) were found to prefer IDS to adult-directed speech (ADS). In addition to garnering increased attention, the exaggerated prosody found in IDS can also be used to highlight a target word, for example. This was demonstrated in Fernald and Mazzie's (1991) experiment examining where and how mothers emphasized words through pitch modulations. Shukla, White, and Aslin (2011) went a step further in a complex task in which 6-month-old infants had to map an auditory word to a single visual object with multiple objects presented simultaneously as potential targets. Prosodic cues were the most helpful to infants with respect to being able to correctly identify the intended referent in the array. Therefore, it is clear that prosodic exaggeration is highly beneficial to infants, not only for grabbing and maintaining attention, but also for the language learning process.

It can be argued that the most important aspect of IDS, however, is its emotional content. Trainor, Austin, and Desjardins (2000) explored whether the prosodic characteristics of IDS, such as exaggerated pitch and slower tempo, may actually be due to the emotion being expressed to the infants by their mothers and other adults. As mentioned previously, infants prefer to listen to IDS; however, they specifically prefer to listen to affectively *positive* IDS rather than affectively *negative* IDS (Fernald, 1993) or neutral ADS (Kitamura & Burnham, 2002; Singh, Morgan, & Best, 2002; Trainor et al., 2000).

When examining the prosodic characteristics of IDS and ADS that have been equated for emotion, Trainor et al. (2000) found surprisingly few differences; most notably, they found that IDS was of a higher pitch overall compared to ADS. Similarly, Singh et al. (2002) found that when equated on emotional content, infants did not show a preference for IDS over ADS, but when the ADS was more positive than the IDS, infants preferred the positive vocal emotion found in the ADS. Interestingly, one of the emotion scenarios Trainor et al. (2000) used for their study, *comfort*, was described as being most similar to the lower-pitched vocal expression of sadness. Therefore, it is likely that infants would have moderate exposure to a voice that adults may characterize as being "sad" due to daily interactions with their mothers, such as when a mother soothes her infant. Overall, however, Trainor et al. (2000) emphasized that it is the emotional connection that is manifest in IDS that is most important for the mother-infant relationship. Also, it is specifically the positive emotion typically found in IDS that is attracting and regulating infants' attention. Therefore, it is this increased attention to the positive emotion in IDS along with other characteristics of IDS (e.g. slow tempo and greater pauses) that may serve to enhance language learning in infants. It is also this point, then, that illustrates why the IDS produced by depressed mothers may be fundamentally different from that of non-depressed mothers.

1.3 - Infants' Responses to Visual Emotion Cues

According to Leppänen and Nelson (2009), emotional salience is most evident in social contexts, such as those involving facial expressions of fear or anger. Preverbal infants are first able to communicate through the detection of and reaction to the emotion expressions of their caregivers and others. Later, infants may use these emotion signals to decide whether or how to approach a novel object in their environment. Infants' ability to encode emotion information from their environment is essential not only for safety reasons, such as observing a fearful face on their mother when misguidedly attempting to go down a set of stairs, but also for fostering a healthy relationship with their caregivers.

However, the manner in which infants look at faces, specifically emotional faces, can vary depending on their prior experience with the various emotions. Whether using interactive social-referencing paradigms or more technology-based designs, such as studies using eye-trackers, it has been shown time and again that infants are able to be influenced by the emotion information they receive. Many times this is seen through changes in attention, such as longer looking durations to different emotion expressions. However, not all infants react in the same way to each emotion, which is why it is important to look at what type of exposure individual infants may have had to different emotions. In the case of maternal depression, it may be that infants of mothers who are suffering from depression are more likely to be frequently exposed to flat or negative maternal affect compared to infants of non-depressed mothers.

For example, an experiment by de Haan, Belsky, Reid, Volein, and Johnson (2004) showed that typically-developing 7-month-old infants' visual and physiological responding to different emotion expressions (happy and fear) varied depending on both maternal personality and infant temperament. In this case, infants who were exposed to mothers who rated themselves as highly positive looked longer at the fearful face than the happy face. This study emphasizes the importance of considering both the individual primary caregiver's emotion tendencies and each infant's temperament.

In addition to accounting for prior exposure to emotion expressions, it is also important to consider the context in which the infant is observing the emotion. One experiment using ERPs by Hoehl, Palumbo, Heinisch, and Striano (2008) examined 7-month-old infants' attention to either a neutral or a fearful face, which were gazing either at a novel object or the infant. Infants' attention increased when the face was expressing fear while looking towards the novel object, but not when the gaze was directed toward the infant. The authors suggested that infants were using social cues, in this case the direction of eye gaze and the fearful expression, to detect and process a potential threat (the novel object). Similar findings have been discovered in social-referencing experiments (e.g. Mumme, Fernald, & Herrera, 1996; Sorce, Emde, Campos, & Klinnert, 1985; Vaish & Striano, 2004).

1.4 - Adults' Responses to Emotional Faces

Much of the research on adults' scanning patterns of emotional faces examines how adults look at threat-related emotion expressions. For example, Bannerman, Milders, and Sahraie (2010) used an attentional cueing task to see how long it took adults to look toward a threat-related fearful face or a neutral face in the periphery. They found that adults had faster saccadic reaction times (SRTs) for fearful faces than neutral faces. In addition, they found that the SRTs to disengage from the fearful face were longer compared to the neutral face. The authors describe this enhanced attentional capture and impaired disengagement as being due to our predisposition to quickly orient towards threat-related stimuli in our environments. In contrast to the attentional capture aspect from the previous study, Becker and Detweiler-Bedell (2009) found that there was no overt attention directed toward fearful faces in a passive viewing task. However, they did find that the adults in the study actively avoided looking at the fearful face. This was also true for angry faces, which they found in a subsequent study. Hunnius, de Wit, Vrins, and von Hofsten (2010) found that both adults and infants avoided looking at threat-related emotional expressions (i.e. angry and fearful), but adults alone avoided eye contact with the threat-related expressions. Unlike the argument for a predisposition or an underlying bias to attend more to threat-related stimuli in the environment found in Bannerman et al. (2010), Becker and Detweiler-Bedell (2009) argue the opposite - that adults look more toward positive stimuli and away from threatening stimuli. Although all three of these studies found a rapid processing of threat-related faces, the behavior following detection varied depending on the methodology.

Like studies with healthy adults, research examining depressed adults' emotion processing typically focuses on differences in attention to threat-related vs. non threat-related emotions. In an eye-tracking study with clinically depressed young adults, Kellough, Beevers, Ellis, and Wells (2008) found that compared to non-depressed individuals, depressed individuals looked for longer times at dysphoric images and for shorter times at positive images when four emotion categories (sad, threat, positive, neutral) were simultaneously presented for 30 seconds. They also found that depressed individuals repeatedly turned their attention back to the dysphoric images, suggesting a sustained or elaborative processing of the sad emotion stimuli. On the other hand, non-depressed individuals showed the opposite pattern, with a greater number of fixations to the positive images. Kellough et al. (2008) interpreted this in favor of a cognitive model in which depressed individuals demonstrate biased attention in favor of negative or dysphoric information. Schofield, Johnson, Inhoff, and Coles (2012) examined dwell time and attention disengagement in depressed and socially anxious adults. They found that for depressed individuals, there was an increase in attention to fearful expressions; for individuals with social anxiety, there was an increase in attention to angry, fearful, and happy faces. Overall, it appears that depressed individuals show difficulty in identifying both basic and mixed emotions (Arsenio et al., 2004), and also show biases towards sad/dysphoric (Kellough et al., 2008) and fearful expressions (Schofield et al., 2012). They also appear to repeatedly return their focus to dysphoric images, while focusing less of their attention to positive images (Kellough et al., 2008).

The studies reviewed above for both infants and adults were all based on unimodal (visual-only or auditory-only) expressions of emotion. However, it is important to examine how receiving information from multiple channels (e.g. audiovisual) affects behavioral patterns towards different emotions as real-life situations are typically of a multimodal nature (Bahrick, Lickliter, & Flom, 2004). Additionally, multimodal information is especially helpful when viewing novel or challenging stimuli.

One study using multimodal stimuli by Kahana-Kalman and Walker-Andrews (2001) examined 3.5-month-old infants to determine not only if there were differences in attention to happy versus sad audiovisual stimuli, but also whether there were differences depending on if the infant was viewing their mother or a stranger. Interestingly, unlike previous studies which demonstrate an attentional bias for threat-related emotions (e.g. Kotsoni, de Haan, & Johnson, 2001; Peltola, Leppänen, Mäki, & Hietanen, 2009; Peltola, Leppänen, Vogel-Farley, Hietanen, & Nelson, 2009), this study found that regardless of person familiarity, infants looked longer at the happy condition than the sad condition. This discrepancy may be in part due to the younger age of these infants, however, as it has been proposed that a “negativity bias” (Vaish, Grossmann, & Woodward, 2010) starts to develop during the second half of the first year. Also intriguing was that infants expressed more frequent and more varied emotions to the happy condition than the sad. These tendencies were enhanced, however, when the infant was viewing their mother instead of a stranger. Therefore, again, even at this young age there is evidence that infants are being influenced by the salient information available to them in their environment. In this case, it is evident in their more intense reactions while observing the positive emotions of their mother.

Infants are also affected by mothers' audiovisual cues conveying warning (Tamis-LeMonda, Adolph, Dimitropoulou, & Zack, 2007). Tamis-LeMonda et al. (2007) found that often mothers will use warnings in a potentially risky situation (e.g. getting too close to a staircase) that would be considered "basic prohibition" category. For example, the mother may say "Stop!" or "Don't!" to keep a child from danger. Additionally, mothers will use affectively-neutral attention-grabbers (e.g. the infant's name), which, combined with the mother's tone of voice or fearful facial expression, could be interpreted as a warning. They also found that the complexity and frequency of the mother's warnings increases as the infant ages and becomes increasingly mobile.

1.5 - Maternal Depression and Language Processing

The characteristics of depressed mothers' speech to their infants and children have been examined in various studies over the years. Reissland, Shepherd, and Herrera (2003) examined the characteristics of depressed mothers' speech through the use of a storybook reading experiment. Storybook reading has previously been found to be an effective tool for language learning, especially when parents have been instructed to ask more frequent and more expansive questions while reading to their children (Whitehurst et al., 1988). Depressed mothers, however, tend to read directly from the text (Reissland et al., 2003). In the same study, it was also found that depressed mothers spoke with a higher pitch to their infants, which in turn may have stressed their infants to the point that the storybook reading activity was no longer an enjoyable activity. This could be partially explained by findings from Breznitz and Sherman's (1987) study comparing depressed and non-depressed mothers' speech characteristics in a mildly stressful and non-stressful situation. One aspect of depressed mothers' speech is that they speak significantly less to their 3-year-old children in a non-stressful situation compared to non-depressed mothers (Breznitz & Sherman, 1987). However, in a stressful situation, the amount of speech actually increased for depressed mothers, but not for non-depressed mothers. Importantly, in the same study it was also found that children of depressed mothers spoke significantly less than children of non-depressed mothers (Breznitz & Sherman, 1987). The authors interpreted their findings such that children of depressed mothers learned to react to stress, even mild stress, in a less adaptive way due to their observations of their mothers' reactions to stress. Therefore, in the Reissland et al. (2003) study, infants of depressed mothers may be interpreting the storybook reading activity as stressful because their mothers are demonstrating signs of anxiety. This difference in depressed mothers' speech patterns was also hypothesized to affect children's language production because depressed mothers' speech was less contingent and consistent when responding to their child's behavior (Breznitz & Sherman, 1987). Depressed mothers include more and longer pauses in their speech that are also less predictable (Zlochower & Cohn, 1996).

Reissland et al. (2003) also found that depressed mothers failed to vary the way they read the storybooks to their infants with respect to the age of the infant. In contrast, non-depressed mothers produced longer mean-length utterances (MLUs) to 10-month-old infants compared to 6-month-old infants. This means that depressed mothers read more of the text at both ages, whereas non-depressed mothers would expand on the storybook reading process with the younger infants. Similarly, Herrera, Reissland, and Shepherd (2004) found that the affective features of depressed mothers' speech did not change for 6-month-old infants compared to 10-month-old infants. However, non-depressed mothers included more affective features (e.g. encouragement, discouragement, laughing, mimicking, and endearment) in their speech to younger infants. They were also found to include fewer information-salient features (e.g. questions, interpretations, and direct statements) in their speech to older infants. The findings from Reissland et al. (2003), Herrera et al. (2004), Breznitz and Sherman (1987), and Zlochower and Cohn (1996) suggest a lack of sensitivity to infants' abilities at different ages for depressed mothers.

In a study examining the predictive effects of depressed mothers' IDS on their children's later emotional functioning, Murray, Marwick, and Arteche (2010) found that, compared to non-depressed mothers, depressed mothers' speech was more repetitive, showed more "creak," and also more falling pitch contours. In addition to more falling pitch contours, Kaplan et al. (2001) also found that there was less modulation in the fundamental frequency (F_0) contour. Together these characteristics lead depressed mothers' speech to sound monotonous and flat, which often comes across as sounding sad, sorrowful, and/or neutral (Scherer, 2003). Because depressed mothers' IDS not only is less effective in both the attention and emotion regulation functions but also is more affectively negative, this may help to explain why their infants show more self-regulatory behaviors like self-touching (Herrera et al., 2004).

Based on the studies described above, it is clear that depressed mothers' speech is different from non-depressed mothers' speech. The acoustic properties of depressed mothers' speech make it less effective as both an attention-getter and an emotion regulation tool. It is often perceived as being sad, negative, or neutral in affect (Scherer, 2003). Depressed mothers also fail to show sensitivity to their infants' needs, both in terms of the contingencies of their vocal responses to their infants and in terms of varying their responses based on the age and abilities of their infants.

Importantly, Kaplan et al. (2009) found that maternal sensitivity significantly predicted infants' learning to his or her mother's infant-directed speech (IDS) even after taking into account maternal depression diagnosis, anti-depressant usage, and demographic variables such as ethnicity and education level. IDS is typically considered to be beneficial for grabbing infants' attention, which may then serve to promote language learning. Therefore, IDS serves as a scaffolding tool for mothers and infants. However, the learning-promoting effects of IDS are not found in depressed mothers' speech, which results in poorer associative learning in infants who have been chronically exposed to maternal depression (Kaplan, Danko, Kalinka, & Cejka, 2012).

As described above, IDS has been found to facilitate infants' language learning by attracting an infant's attention to relevant information in the environment. However, due to the quality of depressed mothers' IDS, infants exposed to maternal depression do not seem to benefit from IDS with respect to language learning. In a series of experiments over several decades, Peter Kaplan and his colleagues have undertaken important research to determine how maternal depression affects learning in infants in different contexts. Using a conditioned-attention paradigm, Kaplan, Bachorowski, and Zarlengo-Strouse (1999) found that when maternal IDS signaled a smiling face, 4-month-old infants of depressed mothers did not exhibit associative learning, whereas infants of non-depressed mothers did show differences in their attention. Depressed mothers did not modulate their speech as often or show as much expansion in their speech contours compared to non-depressed mothers. The authors gave the explanation that the IDS produced by depressed mothers fails to promote associative learning because it does not sensitize infants to the information they are supposed to process.

Interestingly, it is not that infants of depressed mothers are unable to learn, but rather that they fail to learn when listening to their own mother's or another depressed female's speech. This was discovered in a study by Kaplan, Bachorowski, Smoski, and Hudenko (2002), in which 4-month-old infants were exposed to either their own mother's or a stranger's IDS. Infants of depressed mothers were unable to learn to their own mother's or an unfamiliar depressed mother's IDS in a conditioned-attention paradigm. However, they were able to learn to an unfamiliar, non-depressed mother. Infants of non-depressed mothers were able to learn when it was their own or an unfamiliar non-depressed mother, but not when it was an unfamiliar depressed mother's speech. Therefore, it would appear that the prosodic characteristics of depressed mothers' IDS fail to promote associative learning in infants, regardless of whether or not the speaker is familiar to the infant.

An additional study examining 5 ½-month-olds to 13-month-olds infants found that, in contrast to the previous study in which F_0 modulation predicted associative learning, a lack of modulation was not the main predictor for weaker learning for infants of depressed mothers (Kaplan et al., 2009). Instead, maternal sensitivity was the significant predictor for learning. This is in line with the findings discussed above with regards to lower sensitivity found in depressed mothers. It also illustrates the latent inhibition/learned irrelevance hypothesis (described below) that Kaplan proposed as an explanation for why IDS loses its learning-promoting benefits for infants of depressed mothers. It would also explain why the chronicity of maternal depression plays a major role in the weakening of the effectiveness of IDS (Kaplan, Danko, Diaz, & Kalinka, 2011).

When looking more specifically at how these conditioned-attention paradigms predict language scores for infants of depressed mothers, Kaplan et al. (2012) found that 12-month-olds' performances on the associative learning task were significantly, positively related to infants' receptive communication scores on the MCDI. Because infants of depressed mothers show weaker associative learning, it would follow that their scores would be lower than those of non-depressed mothers' infants. Additionally, Quevedo et al. (2011) found that the infants exposed to more chronic depression had worse language scores on the Bayley Scales of Infant and Toddler Development compared to infants not exposed to depression or those only briefly exposed. Stein et al. (2008) found that exposure to maternal depression in the postnatal period, but not at 36 months, was related to lower scores on the comprehension and expressive language subscales of the Reynell Developmental Language Scale at 36 months. Importantly, when the quality of the mother-child relationship was higher, the language scores were also higher. Additionally, depression and poor caregiving were significantly related with one another at 10 months of age, which led to lower scores on the language scales at 36 months. However, low socioeconomic status was also related to lower language scores. Therefore, maternal depression could have the most devastating effect on language development for those infants who also fall in a lower SES bracket.

Finally, in a study examining the effects of antidepressant use and depression on speech perception in infancy, Weikum, Oberlander, Hensch, and Werker (2012) found that infants of depressed mothers who are not on antidepressants show a delay of attunement to their native language properties. The authors attribute this to stimulus deprivation due to a lack of or insufficient exposure to quality IDS.

Overall, maternal depression appears to have a negative impact on infants' language development. This is evident not only in the overall less frequent speech seen in children who were exposed to depression, but also in lower scores on various language scales during infancy and toddlerhood. These negative effects could be explained by the decrease in effectiveness of IDS as described by the latent inhibition/learned irrelevance hypothesis, lower maternal sensitivity, and chronic exposure to maternal depression.

Latent inhibition/learned irrelevance hypothesis. Kaplan et al. (2012) proposed the hypothesis of latent inhibition and learned irrelevance, which are concepts related to the conditioned-attention theory, as a way to describe the decline in the usefulness of IDS to infants of depressed mothers. Essentially, the conditioned-attention theory or paradigm with respect to IDS would be broken down into the different types of stimuli (conditioned and unconditioned), where IDS would be the conditioned stimulus (CS) and, for example, the mother's face would be the unconditioned stimulus (UCS). As described above, depressed mothers tend to show low sensitivity and inconsistencies with their contingent responses; this may result in their infants not learning that IDS signals something they desire, such as their mothers' smiling faces. Therefore, over time, infants of depressed mothers learn to ignore maternal IDS. It no longer is an effective signal to these infants, which demonstrates the concepts of both latent inhibition due to nonreinforcement (low sensitivity) and learned irrelevance due to inconsistent responding. This loss of saliency for maternal IDS would explain why these infants are able to learn from their non-depressed fathers' IDS (Kaplan, Dungan, & Zinser, 2004), but not their depressed mothers' (Kaplan, Bachorowski, Smoski, & Zinser, 2002; Kaplan et al., 2004) or another non-depressed female's (Kaplan et al., 2004). The following section will discuss more fully the typical learning-promoting benefits of IDS for infants, as well as the negative consequences of maternal depression on language learning.

1.6 - Examining Language and Socioemotional Development Together

Lisa Oakes (2009) makes the persuasive argument in her commentary on the state of research in cognitive development in infancy that we should no longer study cognitive abilities such as categorization or memory separately; instead, we should work towards a more complete picture examining how these different abilities or processes work together. This argument should also be applied to the study of language development and socioemotional development. Although rarely studied together, based on the research reviewed above it is clear that language and emotion are inextricably linked, particularly when considering the importance IDS and social referencing play in both. Although there are some studies that do examine emotion and language together, most of these focus on the infant's expression of emotion or of the beginning of emotion talk in infancy. Few studies examine the emotion of the speaker and its effect on associative learning for vocabulary development.

In a study looking more generally at the effects of emotion expression in infants on attention and learning, Rose, Futterweit, and Jankowski (1999) found that 5-, 7-, and 9-month-old infants who exhibited more positive affect, measured by amount of smiling, demonstrated more immature information processing styles compared to infants who exhibited more neutral affect. For example, infants who were more positive looked longer at a photograph and took longer to learn than infants who were more neutral. Those infants had shorter and more frequent looks, and they were able to learn more quickly. Therefore, infants demonstrating more positive affect were classified as "long-lookers," whereas those with neutral affect were classified as "short-lookers."

One study that examined both emotion and language development together found that there was a positive relationship between emotional expression and language in toddlers, which was in line with what they call the mutual facilitation perspective (Kubicek & Emde, 2012). Therefore, early talkers expressed more positive emotion than later talkers. Conversely, later talkers expressed more frequent and more intense fear emotions than early talkers during fear-eliciting tasks. Later talkers had also been rated through parent report as being more fearful in social situations. In contrast with the mutual facilitation perspective, this increase in negative emotion expression for later talkers would be evidence of a competition for resources perspective. Taking both of these findings together, this would actually support their specific emotions perspective, in which the relationship between emotional expression and language development varies depending on the specific emotion.

Bloom and Capatides (1987) also examined the onset of emotion expression and its relationship with language development in infants. Of interest was whether or not emotional valence (positive or negative) of the infant had a detrimental effect on language learning due to the cognitive resources required to express emotions. They contrasted this with time spent with a neutral affect, which they hypothesized would be associated with earlier language development. This reflectivity hypothesis was supported by their results: infants who spent more time with neutral affect had earlier first words, vocabulary spurts, and multiple word use. Importantly, neutral affect in this study was not “flat” affect. It was more similar to the emotion category of interest, in which the infant was attentive, alert, and quiet. In addition, Bloom and Capatides (1987) found that the more often emotions were expressed, the older they were at each of the language milestones (first word, vocabulary spurt, and multiword use). This was in contrast to the emotionality hypothesis, which predicted a positive relationship between emotion expression frequency and number of words spoken at those milestones.

Doan (2010) reviewed recent literature regarding the influence of emotion on word learning during infancy by examining three contexts by which emotion can affect word learning. Several possible mechanisms are addressed, including attention, associative learning, memory, and socio-pragmatic cues. The main hypotheses addressed in the review were 1) whether a preference for affective information results in increases in attention, information processing, and memory, 2) whether maternal attunement to affect scaffolds infants' abilities to use social cues later in childhood, and 3) to examine how experienced emotion helps or hinders language development. To address the first question, Doan (2010) reviews literature supporting the belief that there is more in-depth processing for emotional information. There seems to be some support that emotional valence of the stimulus itself may help infants' associative word-learning recognition, in part due to its attention-grabbing nature. As far as the socio-pragmatic aspect of affect in word learning, Doan (2010) discussed literature that posits that children understand that language is being used to communicate. Additionally, this communication between parent and child may include shared affect or shared attention (e.g. joint attention to an object). For example, Nicely, Tamis-LeMonda, and Bornstein (1999) found that the more often mothers' responses matched their infants in gradient (e.g. intensity or tempo) or valence (positive or negative), the earlier infants reached important language milestones (e.g. first word produced, reaching 50 produced words). Finally, Doan (2010) addressed the effect of an infant's current affective state on word learning. Based on the reviewed studies, Doan (2010) concluded that highly arousing emotion may disrupt word learning by interrupting cognitive processing.

One final argument for the study of emotion and language development together comes from a review by Sohr-Preston and Scaramella (2006) on the impacts of maternal depression on cognitive and language development from infancy to early childhood. In the review, Sohr-

Preston and Scaramella (2006) discussed the language impacts from exposure to depression at different time points for infants. For infants exposed to prenatal depression, the hormones associated with the stress of pregnancy and of depression increase the risk for language delays by affecting attentional systems. Infants exposed to postpartum depression have mothers who are less sensitive to their vocal expressions and needs. They also tend to show withdrawal tendencies, which would correspond to fewer attempts to approach novel objects and environments. As previously described, this may negatively impact their language development by limiting opportunities for word-object labeling by their mothers. Chronic depression has even more negative consequences linked to it, such as lower verbal comprehension skills and school readiness. The lack of maternal sensitivity, minimal positive affect, and frequent displays of flat or negative affect by depressed mothers may negatively impact their infants' abilities to learn about the world around them.

In conclusion, it is important to study socioemotional development and language development together. Although it is not only relevant for depressed mothers and their infants, the relationship between emotion and language is most obvious when examining their interactions. From the poor quality of depressed mothers' IDS and its inability to help infants learn associations, to the inability of depressed mothers to contingently respond to their infants' needs, these infants are at particular risk to language and emotion deficits both during infancy and beyond. Therefore, it is vital that we, as a field, discover how these processes interact in infancy so that we may intervene in the case of maternal depression.

1.7 - Purpose of the Study

Overall, the primary goals of this study were threefold: 1) to discover whether infants learn word-object associations differently depending on the audiovisual emotion being expressed; 2) to examine if and how mother and infant gaze scanning patterns are interrelated as they process various emotion expressions; and 3) to explore whether maternal depression and anxiety symptoms affect infants' emotion and language processing. The following aims or questions address the goals described above.

Aim 1: To determine whether different emotion conditions (happy and neutral) affect infants' abilities to learn word-object associations.

Aim 2: To determine whether mothers' and infants' scanning patterns of positive and negative emotion expressions show similar patterns.

Aim 3: To use eye-tracking technology to provide a clearer picture of mothers' and infants' attention during the emotion task.

In the language task, infants were familiarized to four novel word-object pairings varying in emotion (happy or neutral). It was expected that viewing and listening to a happy speak would facilitate infants' learning of word-object relationships. Specifically, it was expected that infants would fixate longer on and faster towards the target object compared to a distractor object in the happy test trials when prompted with the matching label (c.f. Schafer & Plunkett, 1998). In the neutral test trials, no difference in attention was expected for the target vs. distractor object. As an additional question of interest, it was also expected that infants who look longer at the mouth of the speaker compared to the eyes, regardless of emotion expression, would score higher on the expressive language subscale on the MacArthur Communicative Development Inventory (MCDI; Fenson et al., 2000).

For the emotion task, it was expected that parents and their infants would show similar patterns when scanning the emotion pairs. More specifically, it was expected that there would be significant correlations between the parents' and infants' gaze patterns to the emotion pairs (i.e. direction of first look, duration to each face in the pair).

Finally, the impact of parental depression and anxiety symptoms on each of these tasks was examined. Of particular interest was whether increased depression symptomatology led to a poorer performance on the language familiarization task compared to infants of less or non-depressed mothers.

1.8 - Contributions to the Literature

One potential impact of this experiment is that it is the first eye-tracking study measuring both the parent and the infant on the same task, and there are also no known eye-tracking studies at this point in time for parents with depression or their infants. Using an eye-tracker to test parent and infant separately demonstrated how both parent and infant independently react to presentations of different emotion expressions. Importantly, it is one of the only studies to examine the direct influence of emotion on language learning.

Although not central to this study, the influence of depression symptomatology on learning word-object associations for infants was measured. The impact of parental depression on infants is important to examine due to the known negative consequences both during infancy and later in life to children exposed to maternal depression.

Maternal depression has been found to have negative impacts on both language development and emotion development in particular. During infancy, it has been shown that infants of depressed mothers demonstrate lower attentiveness and empathy and higher arousal compared to a control group (Hernandez-Reif, Field, Diego, & Ruddock, 2006). Kaplan, Danko, Kalinka, and Cejka (2012) found that 12-month-old infants of chronically depressed mothers demonstrated poorer associative learning than they had previously at 4 months. Sohr-Preston and

Scaramella (2006) propose that this puts these infants at risk for language and cognitive delays during childhood.

In addition, a study by the NICHD Early Child Care Research Network (1999) found that 36-month-old children of mothers with chronic depression scored lower on school readiness, expressive language, and verbal comprehension scores. Chronically depressed mothers also rated their children as being more problematic and less cooperative in this study. Tompson et al. (2010) explored maternal depression and its effects on child psychopathology. In their study, they found that maternal depression is strongly related to child depression and other mental health diagnoses in their children. Depressed mothers also reported more of both internalizing and externalizing behaviors in their children. Arsenio, Sesin, and Siegel (2004) also found that, like their mothers, children of mothers with depressive symptoms were not as accurate at identifying or producing different emotions.

This study adds to the technological advances in the language and socioemotional development domains in infancy by using cutting-edge eye-tracking technology to perform tasks that were previously limited in the types of measures that could be employed. For example, instead of relying solely on the measure of “look” or “no look” during word-object learning tasks to determine if an infant learned an association, we are able to say if, when, where, and for how long infants look. This may help illuminate individual differences in infants’ performance on word-object association tasks.

2.0 - Method

2.1 - Participants.

Eighteen 12-month-olds (12 male, 6 female) and their parents (1 male, 17 female, M_{age} = 32.8 years, age range: 22-38 years) were included in the final sample. An additional 8 infants were tested but were not included due to medical problems (*n*=2), unable to calibrate during eye tracking (*n*=3), insufficient valid trials or jitter during eye-tracking (*n*=2), and English not primary language heard at home (*n*=1). Twelve months of age was chosen because it is at a point in time when infants are beginning to say their first words, and they are particularly sensitive to referential cues (e.g. gaze following; Hollich, Hirsh-Pasek, & Golinkoff, 2000). All infants included in the final sample were healthy (by parental report) and within a normal birth weight range (i.e. > 5 pounds, 8 ounces; range: 6 pounds, 6 ounces – 9 pounds, 14.7 ounces). Participants were recruited through the current database maintained by the infant-Language Emotion Attention Perception laboratory, through flyers, newspaper and online ads, and referrals. The sample was representative of the demographics in the surrounding area (Caucasian: *n* = 18). Parents were highly educated (*n* = 16 with both parents having at least a college degree), married (*n* = 17), and middle- to upper-middle-class (*n* = 10 combined income over $80,000/year). All participants received a certificate of participation and $10 in compensation for their participation in the study.

2.2 - Measures

MacArthur Communicative Development Inventory-Short Form. Parents were asked to report on infant communicative skills by completing the short version of the Infant Form of the MCDI (Fenson et al., 2000; see Appendix A). The MCDI contains an 89-word vocabulary checklist with columns for comprehension (Understands) and production (Understands and

Says). The MCDI measures both receptive and vocabulary for 8- to 16-month-old infants and allows one to determine if an infant is above, below, or at the norm for their age. Parents are instructed to check the first column if the child understands but does not yet say the word, and to check the second column if the child understands and says the word. The infant form presents a scope of vocabulary words known to be represented across the 8 to 30 month age range (Fenson et.al., 2000). Words vary in age of acquisition and semantic/structural linguistics. Examples of vocabulary words listed include who, me, uh oh, kitchen, mommy, plant, tooth, and head.

The MCDI has been found to have high internal reliability, with Cronbach's alpha calculated to be .97, as well as acceptable concurrent validity with similar measures (Fenson et.al., 2000). Parents filled out the MCDI during the appointment.

For the current sample, the mean number of words infants understood was approximately 23 words (*SD* = 13.14) and ranged from 4 words to 52 words. This mean falls around the 50^{th} percentile for vocabulary comprehension scores at 12 months (Fenson et al., 2000). The mean number of words infants were able to understand and say was approximately 4 words (*SD* = 3.31) and ranged from 0 to 12 words. Although low, the mean for this sample falls around the 75^{th} percentile for vocabulary production scores at 12 months (Fenson et al., 2000).

Ages and Stages Questionnaire. Parents completed two sections of the 12-month Ages and Stages Questionnaire (ASQ; Bricker & Squires, 1999; see Appendix B). The ASQ identifies children who are at risk of social or developmental delays. The personal-social and communication scales contain 6 items each. The measure can be scored on a Likert scale where 0=Not yet, 5=Sometimes, and 10=Always. The personal-social scale includes questions such as "When you hold out your hand and ask for his toy, does your baby offer it to you even if he doesn't let go of it?" The communication scale includes questions such as "When your baby wants something, does she tell you by *pointing* to it?" The ASQ has been found to have high internal reliability, with Cronbach's alpha calculated to be .97, as well as acceptable concurrent validity with similar measures (Squires, Potter, Bricker, & Lamorey, 1998).

For the current sample, the mean score on the communication scale was in the appropriate range for their developmental age (*M*= 46.39, *SD* = 13.14). However, the range was from 0 to 60 (the maximum range possible). One infant had a score of "0" and fell beyond 3 standard deviations from the mean. This infant was removed from analyses using the ASQ communication scale. All other infants were within 2 standard deviations from the mean. The mean score on the personal-social scale was in the appropriate range for their age (*M*= 45.00, *SD* = 9.85) and ranged from 30 to 60. All infants were within two standard deviations from the mean and within the appropriate range for their age.

Infant Behavior Questionnaire-Revised. Parents also completed the Infant Behavioral Questionnaire-Revised (IBQ-R; 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, such as how much the infant likes to be held and how easy it is calm them down when upset. The measure uses a Likert scale, ranging from 0 ("Never") to 7 ("Always"). An example of a question found on the IBQ is "When introduced to an unfamiliar adult, how often does your baby refuse to go to the unfamiliar person?" Three separate factors have been linked with the items from this measure: Surgency/Extraversion, Negative Affectivity, and Effortful Control. The Infant Behavior Questionnaire has been found to have high internal reliability, with Cronbach's alpha calculated to be .92 for Surgency/Extraversion and .91 for Negative Affectivity, and Effortful Control (Gartstein & Rothbart, 2003). It also has acceptable concurrent validity with similar measures (Gartstein & Rothbart, 2003).

The Surgency/Extraversion factor comprises the Impulsivity, High Intensity Pleasure, and Activity Level scales (Gartstein & Rothbart, 2003). It negatively loads with Shyness, and positively loads with Smiling and Laughter as well as Anticipation (Gartstein & Rothbart, 2003). In the current sample, scores on the Surgency/Extraversion scale ranged from 4.77 to 6.31 (M = 5.44, SD = 0.43).

The Negative Affectivity factor comprises scales related to Sadness, Discomfort, Anger/Frustration, and Fear. It negatively loads with Falling Reactivity/Soothability (Gartstein & Rothbart, 2003). Scores on the Negative Affectivity scale for the current sample ranged from 2.73 to 6.44 (M = 4.01, SD = 0.99).

The Effortful Control factor comprises scales related to Low Intensity Pleasure, Inhibitory Control, Attentional Focusing, and Perceptual Sensitivity. It also positively loads with Smiling and Laughter (Gartstein & Rothbart, 2003). The Effortful Control factor had scores ranging from 4.50 to 6.58 (M = 5.34, SD = 0.44) for the current sample.

Patient Health Questionnaire – 9. All parents who provide informed consent to participate in the study completed the Severity Measure for Depression – Adult screener adapted from the Patient Health Questionnaire – 9 (PHQ-9; Kroenke, Spitzer, & Williams, 2001; see Appendix D). The PHQ-9 has been found to have high internal reliability, with Cronbach's alpha calculated to be .86 and .89 in two different patient samples, as well as acceptable concurrent validity with similar measures (Kroenke et al., 2001).

Parents answered 9 questions regarding their depressive symptoms in the past 7 days. Examples of items from the PHQ-9 include "little interest or pleasure in doing things" and "trouble concentrating on things, such as reading the newspaper or watching television." Items were scored on a Likert scale (0 = "not at all," 1 = "several days," 2 = "more than half the days," and 3 = "nearly every day"). The total scores range from 0 to 27, with higher scores representing greater severity of depression symptomatology. The raw scores for the 9 items were summed and interpreted using the provided cutoff table for the levels of depressive symptoms severity. Scores ranging from 0 to 4 are categorized as "none" (in the current sample, *n* = 16). Scores ranging from 5 to 9 are categorized as "mild depression" (in the current sample, *n* = 2). No parent in the current sample indicated depressive symptoms above the mild range. Although this sample evidenced little to no depression in terms of category labels, their responses can still be conceptualized as indicating number of depressive symptoms on a continuous scale. Within the current sample, the mean number of symptoms was *M* = 2.39, *SD* = 2.15 and ranged from 0 to 9 symptoms. A test for skewness indicated the distribution of scores from this sample had a positive skew (Skewness = 1.84, *SE* = 0.54). Therefore, the scores for this measure were log-transformed to create a normal distribution (Skewness = 0.04, *SE* = 0.54) so that they could be used in the analyses.

In addition, parents answered two "Yes" or "No" questions with regards to their history of depression. Because the PHQ-9 only asks about symptoms for the prior 7 days, it was important to find out if the mother had been depressed at any point after pregnancy and whether or not they used anti-depressants. No parents in this sample circled "Yes" for either question (with regard to the mother).

Adult PROMIS Emotional Distress – Anxiety – Short Form. The Level 2 – Anxiety – Adult PROMIS Emotional Distress – Anxiety – Short Form (Appendix E; www.nihpromis.org) was also administered to the parent, as depression and anxiety are often highly comorbid. For the current study, the form was slightly modified by removing language from the instructions that was not applicable to the study and by removing the two questions that pertain if another individual is completing the questionnaire besides the participant. The content of the questions on the scale was not changed. The Adult PROMIS Emotional Distress- Anxiety measure has been found to have high internal reliability, with Cronbach's alpha calculated to be .79, as well as acceptable concurrent validity with similar measures ($r = .80$; Pilkonis et al., 2011).

Parents answered 7 questions regarding their anxiety in the past 7 days (e.g. “I felt anxious” and “I feel tense”), and were scored on a Likert scale (1=never, 2=rarely, 3=sometimes, 4= often and 5=always), with a range in score from 7 to 35. Scores were summed to obtain a total raw score, which was then converted to a T-score. Anxiety levels for scores less than 55 are considered to be none to slight (in current sample, $n = 15$), scores ranging from 55.0-59.9 are considered to be mild (in current sample, $n = 2$), and scores from 60.0-69.9 are considered to be moderate (in current sample, $n = 1$). No participants scored above 70 (i.e., the highest t-score was 60 for the sample). For the current sample, the mean T-score was in the “none to slight” category ($M = 49.26$, $SD = 6.26$), ranging from 36.30 to 60.00.

Demographics. The demographics questionnaire (see Appendix F) included questions about the infant’s gender, date of birth, parents’ ethnic background, developmental delays (if any), primary language exposed to in the home, birth weight and length, parents’ educational background, and household income.

2.3 - Apparatus and Event Characteristics

Eye-tracking was accomplished using a Tobii© T60 binocular eye-tracker with Studio 3.2 software. Eye movement data were recorded continuously during each task. The Tobii© T60 consists of a 17-inch TFT monitor, which was connected to a desktop computer and monitor. This particular eye-tracking system uses a two-camera system which allows for simultaneous recording of both eye movements. This system minimizes the impact of minor head movements on the calibration of eye position. The sampling rate for this eye-tracking model is 60 Hz, with gaze values being provided every 16.67 ms. The Tobii© T60 is typically accurate to within 0.5 degrees.

The Tobii© Studio 3.2 output provides numerical values indicating the correctness and confidence in each gaze point in the recorded data. Validity scores range from "0" (highest level of confidence) to "4" (lowest level of confidence) and are given for both the left and right eye. Only gaze points that included at least one "0" were included in the final analyses. Gaze points without at least one "0" were filtered out and removed, as they are considered to be corrupt data points (Tobii© Technology AB, 2010). Participants who did not have at least 20% valid fixations across all trials within each task were removed from the sample (n=1).

At the beginning of each task, each participant (infant and parent) was calibrated using a five-point infant calibration procedure. The calibration procedure was repeated for the infant for the emotion task due to the shifting of positions in between tasks. The calibration procedure included a colorful, moving object with an engaging sound which was presented in each of the four corners and the center of the screen. Once the participant was judged to have fixated on the target, the experimenter pressed a key to advance to the next location. Once successful calibration was achieved (i.e. minimal spread from the target from each of the five targets), the task proceeded.

Word-object audiovisual movie clips. Actresses were recorded in front of a green screen at the Virginia Tech Broadcasting Department using professional equipment and editing software. Phrases (see Appendix G) were presented on a teleprompter. Actresses were recorded from just below the shoulders. Each actress said the phrases for each word label with a happy face+voice and a neutral face+voice. The words in each pairing were nonsense words (i.e.

“boog,” “neem,” “jode,” and “pake”) that the infant had not heard before. Every recording was entered into Praat (Boersma, 2001), a program that can be used to analyze speech, in order to perform an acoustic analysis of each phrase (e.g. “Hi baby,” and “Did you see the pake?”). The mean pitch for happy phrases (*M* = 245.79 Hz, *SD* = 33.22) was significantly different from the mean pitch for neutral phrases (*M* = 201.99 Hz, *SD* = 28.70; $t(122) = 11.05$, $p < .001$, $d = 1.41$). Pitch for happy phrases ranged from 51.02 Hz to 443.97 Hz, whereas the pitch for neutral phrases ranged from 50.59 Hz – 202.46 Hz. The mean duration of each phrase was also significantly different for happy (*M* = 1.31 s, *SD* = 0.27) and neutral (*M* = 1.18 s, *SD* = 0.26; $t(122) = 4.21$, $p < .001$, $d = 0.49$).

Animated geometric shapes were superimposed on the videos and served as the “target” and “non-target” objects in this task. These objects were rotated repeatedly in a circular motion. A distractor “non-target” object that the actress did not reference was presented on the opposite side of the target object so that any attentional differences between the two objects during the test trial was likely due to a learning difference and not due solely to familiarity with the target object(s). These will be referred to as the familiar target and familiar non-target below.

Eye-tracking variables. Percent fixation duration, fixation count, and latency were all calculated through examining the raw data output available through the Tobii© Studio program.

Percent fixation duration in the language task was calculated by first summing the total duration to each area of interest (AOI; described below) across the valid trials within each trial and then dividing by the total valid time. This value was then multiplied by 100.

Fixation count was the sum of the number of individual fixations during valid trials only. Fixation count is not necessarily the same metric as percent duration in that equal durations in two separate AOIs can be the result of significantly different individual fixations (e.g., a few long fixations v. several shorter fixations).

Latency was calculated by counting the number of gaze points or frames from when the AOI first became active to when there was a "hit" or fixation on the AOI and multiplying the number by 16.67 ms, which is the duration of each individual frame.

In the emotion task, proportion of the direction of first look was determined by counting the number of times a particular face in the pairing was fixated on first (e.g. fixating on the happy face first in the happy-neutral pairings) and dividing by the number of valid trials for that pairing.

2.4 - Procedure

All procedures and measures were approved by the Institutional Review Board (IRB) at the university prior to testing. At the appointment, the parent completed all questionnaires and the informed consent (see Appendix H) forms except for the ASQ and IBQ, which were sent home with the parent and returned within one week of the test date. Parents also received a list of local mental health resources (Appendix I) in the packet given to them to take home. Once the infant appeared to be comfortable in his or her surroundings, the parent and infant were taken to the eye-tracking room for the first task. The order of task presentation was the same for all infants.

Language task (infant-only). During the language task, infants sat in a highchair facing the Tobii© T60 eye-tracking monitor. The parent sat next to the infant and was instructed not to interact with the infant unless they became fussy. Once successful calibration had been achieved, the language task proceeded as described below.

Infants were familiarized to four novel word-object associations. There were six different test orders, which counterbalanced the order of emotions, actresses, word-object-pairs, and side of presentation. The procedure was repeated two times for each target emotion with new words and objects being used in each emotion condition (happy and neutral).

The female speaker first looked forward at the beginning of each trial and said "Hi baby." The actress then shifted her gaze to the target object on one side of the screen for one second, and then faced forward again while saying short phrases with the word label (e.g. "Do you like the neem?") in the target emotion expression (happy or neutral; see Figures 1a and 1c). This was repeated two more times, so that the actress looked towards the target object and labeled it using different carrier sentences a total of three times. After the first familiarization trial, a "laughing baby" attention-getter was presented for 2 s to center the infants' attention back to the monitor. Following the attention-getter, the same word-object pair was presented with the target object located on the opposite side from the previous trial. Each trial lasted for approximately 18 s.

Following the two familiarization trials, the infant was presented with two test trials in which the infant first saw a blank, black screen for 3 s and heard "Where is the (object label)?" in the matching emotion valence from the familiarization trials. Then, the target object and either a novel object or familiar "non-target" object were both presented on the screen (see Figures 2a and 2b). This objects remained on the screen for 5 s. Order of test trials (non-target vs. novel) and location of objects was counterbalanced within and between participants. After the two test trials were completed, the next word-object pairing was presented. The first two word-object pairings (one happy, one neutral) were considered to be "Block 1," and the last two word-object pairings (one happy, one neutral) were considered to be "Block 2." Between Blocks 1 and 2, a 20 s cartoon played to keep infants engaged with the task. The entire language task lasted approximately 5 m.

Areas of Interest. For the familiarization trials in the language task, dynamic areas of interest (AOIs) were drawn for the eye region, mouth region, familiar target, and familiar non-target (see Figures 1b and 1d). Eye region AOIs were rectangular boxes that extended from just above the eye-brows to mid-way down the nose of the actress. Mouth region AOIs were rectangular boxes that extended from just below the nose to the bottom of the chin area. Because the actresses move in the familiarization trial, AOIs followed the movement of the face. For both the familiarization and test trials, AOIs for each object were drawn using a rectangular box around the object that extended just beyond the actual object.

Emotion eye-tracking procedure. For this task, both the parent and infant viewed the same task, but separately. The parent was tested on the emotion task first, and then the infant was seated in a high chair or on the parent's lap for their testing. While the parent was being tested, the infant was turned around and distracted with toys by a research assistant to ensure that he or she was not able to view the task before testing. The parent was calibrated using the same procedure prior to testing. Infants were calibrated again before proceeding with their test. Following successful calibration, the emotion task was initiated. Both the parent and infant were given the same emotion task sequence. No additional instructions were given to the mother. Three sequences were used for this task, and side of presentation of the emotion expressions was counterbalanced within each sequence. Sequence order was counterbalanced across parent-infant dyads.

A series of pairs of emotion expressions were presented to each participant. These images were taken from the NimStim Face Stimulus Set (Tottenham et al., 2009). Each pairing was presented for 5 s. After each pair, a target was presented in the center of the screen to attract attention back to the same location for the start of each new trial. For parents, each trial was separated by a 2 s black screen with a central white "X" encircled in red (24° visual angle) to center attention on the screen. For infants, the "laughing baby" attention-getter was presented to center the infants' attention back to the monitor. Three emotion pairs (happy-neutral, happy-sad, neutral-sad) were repeated 4 times for a total of 12 pairings. A 20 s cartoon was presented after the first six emotion pairs, and another cartoon was shown after the second block of six pairs. The three "fear" pairings (happy-fear, neutral-fear, and sad-fear) were presented one time each after the second cartoon. These pairs were shown only one time so as to not habituate participants to the fear face. Therefore, there were a total of 15 emotion pairs presented to both the parent and infant.

Areas of Interest. AOIs were drawn for the face, eye region, and mouth region for each emotion in the pair (see Figures 3a and 3b). Face AOIs included all of the face area extending from the top of the forehead down to the chin and from either ear of the actor on the screen. Eye region AOIs were polygons that extended from the forehead to mid-way down the nose. Mouth region AOIs were polygons that extended from just below the nose to the bottom of the chin area.

Free-play interaction task. In order to obtain additional information about the parent-infant relationship, each dyad participated in a free play task that lasted approximately 10 minutes. Interactions were recorded using a multidirectional camera that was controlled by the experimenter from a different room. Because the parents' behaviors were of primary interest for this task, the camera stayed on the parent rather than the infant if they were unable to remain in the same frame. Audio was recorded using an external microphone placed in the interaction task room.

Within the room, there were many toys and books available for the parent and infant to explore. There were also colorful posters of popular cartoons on the walls. There was a rocking chair in the room for parents to sit in, but many parents moved down to the floor to play with their infant during the task. Parents were given minimal instructions for what to do beyond informing them where the camera was located.

Offline coding of parent behavior was completed by undergraduate research assistants who were trained by a graduate researcher in the lab (see Appendix J for full coding scheme, description of the scales, and coding sheet). The primary goal of the interaction task was to measure parental sensitivity. This was achieved using a task adapted from other research labs (Fish, Belsky, & Stifter, 1991; Shapiro & Mangelsdorf, 1994; Calkins, Hungerford, & Dedmon, 2004) and modified for use in this study. There were four Likert scales to measure parental sensitivity: facilitates attention, demonstrates contingency, intrusiveness, and maternal positive affect.

The first scale, facilitates attention, examined to what extent and how skillfully a parent facilitated the infants' responses to a particular object by re-positioning the infant to better see the object and by drawing attention to the object through verbal means (e.g. "See the keys?") or by pointing towards or tapping the object. This scale ranged from 1 ("Very low") to 4 ("Very high"). A score of "very high" meant that the parent exhibited appropriate and facilitative behaviors and seemed tuned in to the infant. A score was given for each 30 second epoch, which was subsequently summed and averaged across epochs. For the current sample, the mean score for facilitates attention was “fairly high” (*M* = 3.00, *SD* = 0.68) with a range from 1.69 to 4 across parents.

The second scale, demonstrates contingency, examined to what extent parents responded directly and in a timely manner to infants’ behaviors. Responding included both verbal and physical responses. This scale ranged from 1 (“Very low”) to 4 (“Very high”). A score of “very high” meant that the parent exhibited consistent and timely responses to the infant’s behavior and seemed tuned in to the infant. A score was given for each 30 second epoch, which was subsequently summed and averaged across epochs. For the current sample, the mean score for demonstrates contingency was “fairly high” (*M* = 3.26, *SD* = 0.61) with a range from 2.04 to 3.92 across parents.

The third scale, intrusiveness, examined to what extent the parent displayed intrusive or over-controlling behavior, which included ignoring the infant’s preferences and re-directing attention. It also included parent’s inability to moderate his or her behavior when the infant demonstrated disinterest or aversion to the parent. This scale ranged from 1 (“Very low”) to 4 (“Very high”). A score of “very high” meant that the parent was consistently intrusive or over-controlling by redirecting the infant’s attention without regard to the infant’s focus of attention. A score was given for each 30 s epoch, which was subsequently summed and averaged across epochs. For the current sample, the mean score for intrusiveness was “very low” (*M* = 1.36, *SD* = 0.38) with a range from 1.00 to 2.63 across parents.

The fourth scale, positive affect, examined to what extent parents conveyed positive emotion to the infant. This included both physical emotion displays and verbal displays. It included behaviors such as smiling, laughing, and nodding in a positive way in response to the infant’s behavior. This scale ranged from 1 (“Very low”) to 4 (“Very high”). A score of “very high" meant that the parent displayed an intense smile or laugh, smiled for a prolonged period during the epoch, and used a more positive tone of voice throughout the epoch. A score was given for each 30 second epoch, which was subsequently summed and averaged across epochs. For the current sample, the mean score for positive affect was "fairly high" (*M* = 2.88, *SD* = 0.59) with a range from 1.78 to 3.73 across parents.

An additional metric used that was not included in the original coding scheme was the number of utterances the parent made. Both lexical and non-lexical utterances were coded. Lexical utterances included the number of words the parent said during each epoch, which was summed and averaged across epochs. In this sample, parents said approximately 38 words per epoch on average (*SD* = 18 words), with a range of 6 to 72 words across parents. Non-lexical utterances (e.g. "shh," "uh huh," etc.) were summed and averaged across epochs. On average, parents made approximately 3 non-lexical utterances per epoch (*SD* = 2 utterances), with a range from 0 to 6 utterances across parents. Krippendorf's alpha, a more conservative measure of inter-rater reliability, was 0.94 for ratings of parents' verbal utterances. A value over 0.81 is considered to indicate near perfect or perfect agreement between raters (Hallgren, 2012). Finally, the number of gestures parents produced was summed and averaged across epochs. Gestures were defined as non-verbal movements (e.g. head nods, pointing, and clapping) that expressed meaning. For parents, approximately 2 gestures per epoch were produced (*SD* = 1 gesture), with a range from less than 1 to approximately 4 utterances across parents. Krippendorf's alpha was 0.92 for ratings of parents' gestures.

3.0 - Results

3.1 - Infant Word-Object Learning: Primary Analyses

Of primary interest was whether infants would form associations between the target nonsense words in the utterances of the female actors and the objects that the actors visually and vocally referenced on the screen. To address this issue, infants' scanning patterns during familiarization and test were analyzed.

Familiarization trials. An Emotion (Happy, Neutral) x AOI (Eye Region, Mouth Region, Familiar Target, Familiar Non-Target) repeated-measures analysis of variance (ANOVA) was performed on percent fixation duration (see Table 1a). There was a significant main effect of AOI such that while on the face, infants fixated longer on the mouth compared to eye region ($t(17) = 2.16$, $p = .05$, $d = 0.93$; see Figure 4). Infants also fixated more on the familiar target compared to the familiar non-target ($t(17) = 6.15$, $p < .001$, $d = 1.25$). No other main effects or interactions were significant.

An Emotion (Happy, Neutral) x AOI (Eye Region, Mouth Region, Familiar Target, Familiar Non-Target) repeated-measures ANOVA was performed on fixation count (see Table 1a and Figure 5). There were significant main effects for Emotion and AOI, both superseded by a significant Emotion x AOI interaction. In the happy trials, infants fixated significantly more often on the mouth compared to eye region ($t(17) = 2.29$, $p < .05$, $d = 0.99$). In contrast, there was no difference in fixation count to the mouth region v. the eye region during neutral trials ($t(17) = 1.87$, $p > .05$, $d = 0.81$). Fixation count on the familiar target object was greater than on the familiar non-target object independent of emotion type (Happy: $t(17) = 4.55$, $p < .001$, $d = 1.04$; Neutral: $t(17) = 5.72$, $p < .001$, $d = 1.24$).

An Emotion (Happy, Neutral) x AOI (Familiar Target, Familiar Non-Target) repeated-measures ANOVA was performed for the latency to look at the objects (see Table 2a). The latency to shift attention to the object AOIs was calculated only once the AOIs had become activated (i.e., once the actor turned toward the object). There was a significant main effect of AOI, such that infants first fixation to the familiar target object was faster (M = 2532.68 ms, SE = 358.16) compared to the familiar non-target object (M = 6849.29 ms, SE = 779.98; $t(17) = -6.33$, $p < .001$, $d = 1.68$). The main effect of Emotion and the Emotion x AOI interaction were not significant.

Test trials. An Emotion (Happy, Neutral) x AOI (Familiar Target, Non-Target) repeated-measures ANOVA was performed for percent fixation duration on the familiar target vs. non-target objects (i.e., collapsed across novel non-target and familiar non-target objects; see Figure 5). All main effects and interactions were nonsignificant (see Table 3a).

Although the interaction was nonsignificant, post-hoc paired tests were conducted to compare time on familiar target vs. the non-target within each emotion. During the happy test trials, infants fixated significantly longer on the non-target compared to familiar target object ($t(17) = 2.91$, $p < .02$, $d = 1.00$). In contrast, there was no difference in fixation duration on familiar target vs. non-target during neutral test trials, ($t(17) = -0.17$, $p = .87$, $d = 0.06$; see Figure 6).

An Emotion (Happy, Neutral) x AOI (Familiar Target, Non-Target) repeated-measures ANOVA was performed on the number of fixations to the familiar target vs. non-target during test trials. There were no significant main effects or interactions (see Table 3a).

An Emotion (Happy, Neutral) x AOI (Familiar Target, Non-Target) repeated-measures ANOVA was performed on latency of first look to the familiar target vs. non-target during test trials. There were no significant main effects or interactions (see Table 3a).

In this experiment, there were two types of test trials: familiar target with novel non-target object and familiar target with familiar non-target object. Due to the literature on novelty preferences being evidence of learning in word-object association paradigms, attention to the two kinds of non-target objects in each test trial was explored further.

An Emotion (Happy, Neutral) x AOI (Familiar Target, Novel Non-Target) repeated-measures ANOVA was performed on percent fixation duration to the familiar target vs. non-target (see Table 3b and Figure 7). There was a significant main effect of AOI. Infants fixated longer on the novel non-target compared to the familiar target (d = 0.82). There was no significant main effects of Emotion. Although the Emotion x AOI interaction was nonsignificant as well, paired comparisons were conducted for attention to each object within emotion. In the happy trials, infants looked significantly longer at the the novel non-target object compared to the familiar target object ($t(17) = 2.75$, $p = .01$, $d = 1.10$). In the neutral trials, there was no difference in attention to the familiar target object v. novel non-target ($t(17) = 2.75$, $p = .01$, $d =$ 0.13).

Two separate Emotion (Happy, Neutral) x AOI (Familiar Target, Novel Non-Target) repeated-measures ANOVAs were performed for the number of fixations and the latency of the first look to the familiar target vs. novel non-target. There were no significant main effects or interactions for fixation count or latency (see Table 3b).

Three separate Emotion (Happy, Neutral) x AOI (Familiar Target, Familiar Non-Target) repeated-measures ANOVAs were performed for percent fixation duration, fixation count, and latency to the familiar target vs. familiar non-target (see Table 3c). There were no significant main effects or interactions for any of the three metrics.

3.2 - **Infant Word-Object Learning: Secondary Analyses**

Although predictions for differential scanning patterns as a function of speaker emotion were made with respect to infants' performance across the entire word-object learning task, it is possible that differential evidence for learning occurs when examining performance early v. later during their sessions. To examine time effects, the same analyses presented above were repeated by first (Block 1) vs. second (Block 2) halves of the sessions.

Familiarization and Test trials: **Block 1.** Analyses on Block 1 data did not differ in outcome to those listed above for percent fixation duration, fixation count, and latency (see Table 1b and 2b).

Familiarization trials: Block 2. An Emotion (Happy, Neutral) x AOI (Eye Region, Mouth Region, Familiar Target, Familiar Non-Target) repeated-measures ANOVA was performed on percent fixation duration for Block 2. As with the analysis on whole session data above, there was a significant main effect of AOI but additionally a significant interaction between Emotion x AOI interaction in Block 2 only (see Table 1c and Figure 8). During Block 2 happy trials, infants fixated significantly longer on the mouth compared to eye region ($t(17) = 2.58$, $p < .05$, $d = 1.09$; Figure X). In contrast, there were no differences in percent fixation duration to the eye region vs. mouth region in the neutral trials ($t(17) = -1.64$, $p > .05$, $d = 0.67$). Infants fixated significantly longer on the familiar target compared to familiar non-target for both happy ($t(17) = 2.74$, $p = .01$, $d = 0.71$) and neutral trials ($t(17) = 4.02$, $p = .001$, $d = 0.99$).

The outcomes of the analyses for fixation count and latency during Block 2 did not differ from those for the full analyses (see Table 1c and 2c, respectively).

3.3 - Relationships between Word-Object Learning, Temperament, and Language Skill

In addition to examining scanning patterns during familiarization and test, it was also of interest to relate aspects of scanning to measures of infants' temperament and language skills. Given the specific prediction that infants who fixated the mouth region more would show higher vocabulary skill, bivariate correlations were performed on each of the communication and language-related infant questionnaires (e.g. MCDI receptive and productive vocabulary, ASQ personal-social and communication scales) and percent fixation duration on mouth region, eye region, familiar target and familiar non-target from the familiarization phase of the word-object learning task (see Table 5a) and familiar target and non-target (collapsed across target type) from the test phase of the same task (see Table 5b).

For familiarization (Table 5a), the only significant correlation for the MCDI was between the production score and fixation on the mouth in the neutral condition ($r = .46$, $p < .05$). The only significant (and negative) correlation for the ASQ was between the personal-social scale and fixation on the familiar target in the happy condition ($r = -.49$, $p < .05$). Interestingly, there were also significant positive correlations between IBQ negative affectivity and fixation to the eye region in both emotion conditions (both $r = .64$, $p < .01$).

During the test trials (Table 5b), neither the MCDI scores nor the ASQ scores were correlated with any fixation patterns. However, the IBQ effortful control scale was negatively correlated with fixation on the non-target during the happy condition ($r = -.46$, $p < .05$).

3.4 - Infant and Adult Scanning of Paired Emotion Expressions

Another interest of this study was to examine scanning patterns of infants and their parents as they viewed standardized emotion expressions of happy, sad, neutral, and fear in pairs. First, group-level analyses of infants' and adults' performance on this task will be presented. Analyses of concordance between parent-infant dyads are presented in a subsequent section below.

Direction of first looks. The proportion of first looks within each emotion pair was compared to chance (0.5) to determine if either infants or adults showed an initial bias toward one emotion expression. For infants, no significant bias was present. For adults, the proportion of first looks toward the happy face in the happy-sad pairing was significantly above chance (M = .63, SE = .05; $t(17) = 2.70$, $p < .05$).

Percent fixation duration. Emotion (Emotion 1, Emotion 2) x Viewer (Infant, Adult) repeated-measures ANOVAs were performed to examine attention to each face in each emotion pairing (see Table 4). Figures 9a and 9b show the means and standard errors for infants' and parents' percent fixation duration to the faces in each emotion pairing.

In general, infants did not show any differences in percent fixation duration for either face in any of the six pairings except in the sad-fear pairing: infants fixated longer on the fear face compared to the sad face. In contrast, adults showed a positivity bias in the pairings including a happy face, in that attended longer to the happy face compared to the other face in the pair. However, there was no significant difference in percent fixation duration between faces in the neutral-sad and neutral-fear pairings, while in the sad-fear pairing they showed a fear bias.

Additionally, Emotion (Emotion 1, Emotion 2) x Viewer (Infant, Adult) x AOI (Eye Region, Mouth Region) repeated-measures ANOVAs were performed on each pairing. There were significant Viewer x AOI interactions in each pairing. Infants generally had a mouth region bias across all pairings except in neutral-fear where there was no significant difference in attention to the eye region vs. mouth region (see Figure 10a). In contrast, adults had an eye bias in all pairings except sad-fear and happy-fear where they showed no difference in attention to the eye vs. mouth region (see Figure 10b). Interestingly, there was also a significant Emotion x AOI interaction in the happy-fear pairing such that the percent fixation duration was significantly greater to the fear eye region compared to the happy eye region for both infants and adults ($t(14) = 3.57$, $p < .05$, $d = 0.88$).

3.5 - Infant-Parent Dyadic Correspondence in Emotion Processing

In order to examine whether specific infant-parent dyads were similar in their patterns of emotion scanning during the second task, correlations were computed between individual infant-parent dyads' attention to each emotion pairing, both in terms of attention to each face as well as allocation of attention to AOIs (eye vs. mouth region). Only during the happy-fear pairing were infants' and parents' attention to the happy face positively correlated ($r = .54$, $p < .05$). No other correlations were significant. Correlations were also computed between individual infant-parent dyads' proportions for direction of first looks. However, none of these correlations were significant (all *p*s > .05).

In addition to parent and infant scanning patterns, it was also possible to look for relationships between certain parent characteristics (e.g. PHQ-9 log-transformed scores, PROMIS Anxiety Scale scores, and parental sensitivity composite score) and their infant's emotion processing. There was a significant, negative correlation between parents' depression symptomatology and infants' attention to the fear face in the happy-fear pairing ($r = -.53$, $p < .05$). Additionally, there was a significant, negative correlation between parents' anxiety symptomatology and infants' attention to the fear face in the happy-fear pairing ($r = -.62$, $p < .05$) as well as a significant, positive correlation between parents' anxiety scores and infants' attention to the happy face in the happy-fear pairing ($r = .59$, $p < .05$). There were no other significant correlations (all *p*s > .05).

Correlations were also performed on each of the parent measures (i.e. log-transformed PHQ-9 depression measure, PROMIS Anxiety Scale, and parental sensitivity scores) and the language task measures. Three of the parental sensitivity scales (facilitates attention, contingency, and positive affect) for the free-play task were positively correlated with one another (all *r*s $\geq .8$ and *p*s $< .001$), so a composite for parental sensitivity was created and used for all subsequent analyses ($M = 3.05$, $SD = 0.60$). Individual inter-rater reliability values for the facilitates attention, contingency, and positive affect scales (Krippendorf's alpha = 0.82, 0.87, and 0.81, respectively) and the composite of these scales (Krippendorf's alpha = 0.82) were all adequate. Number of parental gestures during the free play task was negatively correlated with attention to the non-target object during the test trials (Neutral: $r = -.47$, $p < .05$; Happy: $r = -.45$, $p = .06$). All other correlations with the language task measures were nonsignificant (all *p*s > .05).

Next, bivariate Pearson correlations were performed to examine how parents' and infants' scores on the questionnaires and free-play task were related. Parents' gestures were also positively correlated with their own lexical and non-lexical utterances ($r = .57$, $p = .01$ and $r = .49$, $p < .05$, respectively). Additionally, higher scores on the parental sensitivity composite were positively correlated with the number of lexical utterances and parent gestures made during the free play task ($r = .80$, $p < .001$ and $r = .57$, $p = .01$). Parents' anxiety scores were positively correlated with infants' receptive and productive vocabulary scores on the MCDI ($r = .52$, $p < .05$ and $r = .46$, $p = .05$, respectively).

3.6 - Correlation Analyses for Parent Characteristics

There were no significant correlations with depression or anxiety symptomatology and attention to any of the faces in the pairings. Since parents fixated longer on the eye region than mouth region in all but one of the pairings, attention to the eye (*M* = 65.91%, *SE* = 4.33) and mouth regions (*M* = 30.05%, *SE* = 4.13) was collapsed across emotion pairings. There were no significant correlations with either depression or anxiety symptomatology and attention to the eye and mouth regions.

4.0 - Discussion

The primary purpose of this study was to examine the nature of the intersection between emotion and language processing around the end of an infant's first year. Based on literature on the learning-promoting features of infant-directed speech (c.f., Fernald and Mazzie, 1991), typically rated as "happy" (Singh et al., 2002), as well as the learning deficits seen in infants' responses to depressed mothers' speech (e.g. Kaplan et al., 1999; Kaplan et al., 2002; Kaplan et al., 2012), typically rated as "flat" or "negative" (Scherer, 2003), it was predicted that listening to and watching happy speakers would facilitate 12-month-old infants' learning of word-object pairs. Specifically, I expected to see increased scanning of and faster orientation to the target object in the happy test trials only, which would be evidence of infants' learning of the word-object relationship during the happy familiarization trials. This hypothesis was partially supported. Infants exhibited indications that they had learned the word-object associations during the happy trials only. However, rather than more attention being directed towards the familiar target object (such as in Schafer and Plunkett, 1998), infants' attention was instead on the non-target object, particularly when the non-target was novel (i.e., an object that had not appeared on the screen during familiarization). When tested with familiar target v. familiar non-target objects (i.e., the object on the screen during familiarization that was *not* referenced), no differential attention occurred.

Importantly, the finding that infants showed a *novelty* preference during the happy test trials can be taken as evidence of their learning of the word-object association during familiarization (Aslin, 2007). There is a large body of work on infants' novelty and familiarity preferences following familiarization. Typically, infants show increased attention to a novel vs. familiar event during test trials if they were able to fully encode the repeated stimulus during familiarization (c.f. Houston-Price & Nakai, 2004). For example, using a referential learning paradigm (similar to that used in the current study) but with a live speaker, 13- and 18-month-old infants were more likely to choose the target toy during the “extension” trial rather than the “mapping” trial (Campbell & Namy, 2003). Campbell and Namy (2003) attributed this difference in attention between test trial types to a novelty preference for the distractor object in the “mapping” trial, which is similar to the test trials in the current study. However, in a study similar to this one in that it uses audio prompts to get infants to match a newly-learned word label to the correct object image, Schafer and Plunkett (1998) found the opposite: infants attended more to the matching rather than non-matching image. Thus, it is not always consistent across word-object learning studies as to whether “learning” will manifest in the same way: some find that infants attend more to familiar word-object presentations whereas others find they attend more to novel word-object presentations (or violations of familiar word-object pairings; c.f. Werker, Cohen, Lloyd, Casasola, & Stager 1998).

Aslin (2007) describes the circumstances under which a familiarity preference may be found, including when infants are presented with stimuli too complex or diverse to fully encode during familiarization or, alternatively, some components or dimensions of an encoded stimulus may lead to a recognition response rather than attentional response to novelty. In the Schafer and Plunkett (1998) study, the authors describe their own stimuli as “strange” (i.e. multi-colored, multi-textured, with occlusions or shadows to portray depth), making it entirely plausible that this complexity and/or diversity attenuated infants’ ability to fully encode the information. In the current study, the familiar target and both familiar and novel non-target objects were counterbalanced across emotion, actress, side of presentation, and color. None of the objects used had extraneous sub-components or multiple colors, textures, etc. Therefore, it is possible that the findings from this study are in the opposite direction from Schafer and Plunkett (1998) due to these dissimilarities in object characteristics.

The objects used in the current study also had identical clock-wise movement, which was important given the findings from Werker et al. (1998) indicating 14-month-old infants only learned word-object associations when the objects were moving and the movement needs to be identical across stimuli in order to rule out the possibility that infants' were simply recognizing the movement of the objects rather than learning the label associated with them. Additionally, Gogate, Walker-Andrews, and Bahrick (2001) discuss the importance of movement in terms of its ability to enhance the detection of arbitrary relations between objects and word labels for infants at 12 months of age.

That this novelty bias occurred only for the happy word-object pairings they were familiarized to is evidence that having a happy speaker facilitated their learning of the association. Overall, attention duration between the happy and neutral familiarization trials did not differ, which means that there was some other specific aspect of the happy speakers that promoted learning. One possibility is the increased number of fixations to the mouth region in the happy trials, which was not seen in the neutral trials. Visual speech is known to help younger infants with phoneme discrimination (Teinonen, Aslin, Alku, & Csibra, 2008). Also, words and sounds that come from the mouth, as opposed to digitized object sounds, have also been found to enhance word learning (Hollich et al., 2000). Hollich et al. (2000) go so far as to call these instances "privileged." In the current study, enhanced focus on the mouth of the speaker in the happy condition may have led to better, more accurate encoding of the word being spoken in reference to the object being visually regarded.

Additionally, it was predicted that infants who looked longer at the mouth region of the speaker, regardless of emotion, would have higher vocabulary scores on the MCDI, particularly productive scores (c.f. Young et al., 2009). However, this expectation was only partially supported. First, there were no significant correlations between infants' scanning of eye or mouth regions and receptive vocabulary. Also, collapsing across emotion, there was no relationship between attention to the eye or mouth regions and productive vocabulary scores. However, attention to the *neutral* mouth was positively correlated with productive vocabulary scores, but not attention to the happy mouth. Therefore, it may be that infants who have higher vocabulary scores are the ones who are already more likely to look at speakers' mouths. Why would this advantage accrue only during the neutral displays?

One possibility is that the happy displays represent the kinds of ostensive conditions that promote attention for most infants: smiling faces and positive prosody in voice and facial features. Thus, more infants are likely to accomplish word-object learning in the happy condition compared to the neutral condition when these ostensive cues are dampened. Several studies have shown superior learning of various aspects of individual words and/or words embedded in sentences when the speech is ID in its style (e.g., Fernald & Kuhl, 1987; Newman & Hussain, 2006). In fact, infants as old as 18 to 20 months still require what Gogate et al. (2001) call a social criterion – a speaker expressing visual interest in objects while naming them – in order to learn word-object associations (Baldwin et al., 1996). Gogate et al. (2001) also expound on the importance of socially-contingent contexts (e.g. social referencing) that enhance infants' ability to identify word-object relations; specifically, they point to the importance of "multimodal motherese" in assisting infants' development.

On the other hand, infants who are particularly good at controlling their own attention will continue to focus on the mouth of the speaker and the object in the neutral condition, and it is this subset of infants who show advantaged vocabulary. However, this explanation is not supported by the lack of a correlation between attention to mouth during neutral trials and effortful control in the IBQ.

Another approach to understanding differences in infants' vocabulary skills was to examine the frequency of parents' lexical and non-lexical utterances and non-verbal gestures during interaction with their infant with the language measures. Interestingly, the number of parents' lexical and non-lexical utterances was positively correlated with the number of non-verbal gestures they used. This is consistent with findings from Iverson, Capirci, Longobardi, and Caselli (1999) in that parents' gestures tended to co-occur with speech. Therefore, parents who were more verbal with their infant also used more gestures to convey meaning to their infant. However, there were no significant correlations between either utterance or gesture frequency and infant vocabulary scores. Iverson et al. (1999) provide the term "gestural motherese" to describe the potential function of the gestures parents use to reinforce verbal messages, which also provides intersensory redundancy (Bahrick et al., 2004). Both parental verbal utterances and gestures are important predictors of children's language abilities (Iverson et al., 1999). The lack of correlation between these variables and infants' MCDI scores or language task measures in the current study may be attributable to infants' ages. That is, infants in this sample may have been too young to see this relationship since they were at the beginning of their word production (MCDI productive range 0 – 12). For this sample, only four words on average were both understood and spoken. Therefore, it would be beneficial and informative to follow up with these infants to see if parents' utterances and gestures at 12 months predict their infants' vocabulary at a later age (e.g., 24 months of age).

Another important predictor of language development in infancy is parental sensitivity, encompassing behaviors such as social referencing, joint attention, and contingent responding. Although infants were not viewing their own parents or a live experimenter during the language task, this was not merely a word-object association task but a referential learning task. Infants had both ostensive (e.g. "Hi baby" and corresponding direct eye gaze; IDS) and social referential cues (e.g. eye gaze shift and simultaneous head-turn towards the object; emotion valence) available to them, which are both known to assist infants in learning about objects (Waxman & Gelman, 2009; Wu, Tummeltshammer, Gliga, & Kirkham, 2014). Parental sensitivity was directly examined through the free-play task, where variables such as facilitating attention, contingent responding, and positive affect were measured. Based on the literature review on maternal sensitivity, it was predicted that sensitivity during the free-play task would relate to various aspects of infants' language processing. However, there were no significant correlations with parental sensitivity and any of the language measures, including vocabulary. Although sensitivity was not correlated with infant characteristics, it was positively correlated with parental utterances and gestures. As mentioned above, it may be that parents' sensitivity at 12 months is related to their infants' language skills, but not until they are older.

4.1 - Infant-Parent Dyadic Correspondence in Emotion Processing

The second goal of this study was to examine infant-parent correspondence in emotion processing. Based on studies examining relationships between parents' emotion disposition and infants' processing of facial expressions of emotion (e.g. de Haan et al., 2004), it was expected that infants and their parents would demonstrate similar gaze patterns when viewing pairs of emotions. However, this was only the case in the happy-fear pairing, such that infants' and parents' attention to the happy face were positively correlated. Interestingly, de Haan et al. (2004) used sequential presentations of static happy and fear faces in their experiment, but they found that 7-month-old infants with mothers who self-reported as being highly positive looked longer at the fear face. In the current study, the correlation between parental positive affect during the free-play task and infants' attention to the fear or happy face was nonsignificant. However, parents' depression and anxiety symptomatology and infants' attention to the fear face were negatively correlated. Because both of these studies used correlational analyses, it is not possible to say whether parents are influencing their infants' responding to emotions so the question of how or if parents influence infants' emotion processing remains.

Although it had been predicted that infants' and parents' gaze patterns would be correlated, this was not supported by the scanning patterns during the emotion task. In general, infants did not show any significant attentional differences to either face in the emotion pairs, except for a fear bias in the sad-fear pairing. On the other hand, parents demonstrated a bias for the happy face when it was presented regardless of the other paired emotion, but also a fear bias in the sad-fear pairing. Infants' lack of a clear bias (positivity or negativity) is surprising given the extensive literature on this matter (c.f. Vaish et al., 2008). Also surprising was the strong mouth bias infants had for these stimuli given that they were static, silent photographs. Traditionally, an eye bias is seen for static faces (e.g., Hunnius et al., 2011). In fact, this is what was found for the adults in the sample. There was a clear eye bias in all pairings except for two: happy-fear and sad-fear. It is unclear when this developmental shift from attention to the mouth to the eyes happens, though several studies have investigated such biases (e.g. Lewkowicz & Hansen-Tift, 2012). Lewkowicz and Hansen-Tift (2012) found a shift from mouth to eye region around 12 months while viewing and listening to speakers of their native language. However, in both the language task and emotion task in the current study, there was significantly more attention to the mouth region compared to the eye region. One potential reason for the mouth bias in the emotion task is that it was preceded by the language task, which used dynamic, bimodal displays of emotion. Therefore, it is possible that infants were primed to look at the mouth. Counterbalancing task order in the future could determine whether this hypothesis is supported. Another possible explanation is that infants are differentially focused on the mouths of speakers as they approach the time to begin speech production, and that this bias may continue through the period of their first "language explosion" (Hollich et al).

4.2 - Parental Depression and Anxiety

A final interest in this study was how parents' depression and anxiety symptomatology influenced both their own and their infants' cognitive and socioemotional behaviors. Based on prior literature on maternal depression, it was expected that higher levels of depression symptoms would be predictive of poorer word-object learning and lower scores on the vocabulary measures. Additionally, mothers with depression are thought to be less sensitive (e.g. Campbell, Cohn, & Meyers, 1995; Kaplan et al., 2009), so it was expected that depression scores would be negatively correlated with parental sensitivity from the free-play task. No such relations were found, possibly due to the limited number of depression symptoms indicated on the PHQ-9 depression measure. Given the low-risk nature of this parent sample, the lack of correlation with other measures is most likely due to insufficient variability in depressive symptomatology.

On the other hand, there were two significant findings with parents' anxiety symptoms. First, parents' anxiety symptoms positively related to infants' gaze on the happy face but negatively related to infants' gaze on the fear face only during the happy-fear pairing. A possible explanation for this pattern is that increased attention to the happy face is a result of a novelty effect for infants with more anxious parents (see argument above regarding novelty preferences; Aslin, 2007). Anxious parents may display less positive affect, so that may explain why infants of parents with more anxiety symptoms looked less to the fear face. Interestingly, parents' anxiety symptomatology was positively correlated with infants' receptive and productive vocabulary. This suggests that anxious parents talk more to their infants, resulting in a boost in their infants' receptive and productive vocabulary scores. Importantly, the average scores for parents on the anxiety measure put this sample in the none-to-slight categorization. Thus, this interpretation is a cautious one, and we might expect that in a larger, broader sample, even higher parental anxiety would be negatively correlated with infant language scores.

5.0 - Conclusion

The purpose of this study was to examine how several factors intersect with infants' language and socioemotional development. First, the role of emotion in word-object learning was explored using happy and neutral speakers. Based on the results of this study, it does appear that listening to and viewing a happy speaker facilitates word-object learning, whereas infants did not demonstrate evidence of learning word-object associations with a neutral speaker. Second, infant-parent correspondence in gaze processing of emotion was explored. In general, it does not appear that infant-parent dyads show similar gaze patterns. However, there were some instances of parent characteristics (e.g. depression and anxiety symptomatology) potentially playing a part in how infants attend to happy and fear emotion expressions. Finally, the role of parental sensitivity and communicative behavior during a free-play task on infants' language and socioemotional development was investigated. Parents who were more sensitive also exhibited more frequent communicative behaviors (e.g. lexical utterances and gestures). Although there were no significant correlations with these behaviors and the current measures of infants' language and emotion processing, it may simply be too early to tell if they will be able to predict infants' language skills and emotion processing tendencies.

Overall, this study provides several important findings for the field. However, many additional questions remain. Future directions for the current study will include a more nuanced examination of gaze patterns (e.g. length of first fixation), physiological responding using pupil size, and a more in-depth analysis of the free-play task. Additionally, follow-up examinations of the infants in the sample will be collected to see if the current measures are predictive of infants' language development at a later age. In conclusion, these findings add to the paucity of research examining the intersection of language and socioemotional development in infancy.

References

Ainsworth, M. D. S., & Bowlby, J. (1991). An ethological approach to personality development. *American Psychologist, 46,* 331-341. doi: http://dx.doi.org/10.1037/0003-066X.46.4.333

Als, H., Tronick, E., Lester, B.M., & Brazelton, T.B. (1977). The Brazelton Neonatal Behavioral Assessment Scale (BNBAS). *Journal of Abnormal Child Psychology, 5*, 215-231. doi: 10.1007/BF00913693

Arsenio, W.F., Sesin, M., & Siegel, L. (2004). Emotion-related abilities and depressive symptoms in Latina mothers and their children. Development and Psychopathology, 16, 95-112. doi: 10.1017/S0954579404044426

Aslin, R.N. (2007). What's in a look? *Developmental Science, 10*, 48-53. doi: 10.1111/j.1467-7687.2007.00563.x

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

Baldwin, D.A., Markman, E.M., Bill, B., Desjardins, R.N., Irwin, J.M., & Tidball, G. (1996). Infants' reliance on a social criterion for establishing word-object relations. *Child Development, 67*, 3135-3154. doi: http://www.jstor.org/stable/1131771

Bannerman, R.L., Milders, M., & Sahraie, A. (2010). Attentional bias to brief threat-related faces revealed by saccadic eye movements. *Emotion, 10*, 733-738. doi: 10.1037/a0019354

Becker, M.W., & Detweiler-Bedell, B. (2009). Early detection and avoidance of threatening faces during passive viewing. *The Quarterly Journal of Experimental Psychology, 62*, 1257-1264. doi: 10.1080/17470210902725753

Bhullar, N., Panneton, R.K., Kim, J., Heck, A., & Dunbeck, K. (2012). *Lexical processing in older infants is mediated by speaker emotion*. Manuscript in preparation.

Bigelow, A.E., MacLean, K., Proctor, J., Myatt, T., Gillis, R., & Power, M. (2010). Maternal sensitivity throughout infancy: Continuity and relation to attachment security. *Infant Behavior and Development, 33*, 50-60. doi: 10.1016/j.infbeh.2009.10.009

Bloom, L., & Capatides, J.B. (1987). Expression of affect and the emergence of language. *Child Development*, *58*, 1513-1522. doi: http://www.jstor.org/stable/1130691

Boersma, P. (2001). Praat, a system for doing phonetics by computer. *Glot International*, *5,* 341-345.

Bretherton, I. (1992). The origins of attachment theory: John Bowlby and Mary Ainsworth. *Developmental Psychology*, *28*, 759-775. doi: http://dx.doi.org/10.1037/0012-1649.28.5.759

Breznitz, Z., & Sherman, T. (1987). Speech patterning of natural discourse of well and depressed mothers and their young children. *Child Development*, *58*, 395-400. doi: http://www.jstor.org/stable/1130516

Bricker, D., & Squires, J. (1999). Ages and Stages Questionnaires: A parent-completed child-monitoring system. Baltimore, MD: Paul H. Brookes Publishing Co.

Calkins, S. D., Hungerford, A., & Dedman, S. E. (2004). Mothers' interactions with temperamentally frustrated infants. *Infant Mental Health Journal*, *25*, 219-239. doi: 10.1002/imhj.20002

Campbell, A.L., & Namy, L.L. (2003). The role of social-referential context in verbal and nonverbal symbol learning. *Child Development, 74*, 549-563. doi: http://dx.doi.org/10.1037/0012-1649.31.3.349

Campbell, S.B., Cohn, J.F., & Meyers, T. (1995). Depression in first-time mothers: Mother-infant interaction and depression chronicity. *Developmental Psychology, 31*, 349- 357. doi: http://psycnet.apa.org/doi/10.1037/0012-1649.31.3.349

Cohn, J.F., & Tronick, E.Z. (1983). Three-month-old infants' reaction to simulated maternal depression. *Child Development, 54*, 185-193. doi: http://www.jstor.org/stable/1129876

Cooper, R. P., Abraham, J., Berman, S., & Staska, M. (1997). The development of infant preference for motherese. *Infant Behavior and Development, 20*, 477-488. doi: 10.1016/S0163-6383(97)90037-0

Cooper, R.P., & Aslin, R.N. (1990). Preference for infant-directed speech in the first month after birth. *Child Development, 61*, 1584-1595. doi: 10.1111/j.1467-8624.1990.tb02885.

de Haan, M., Belsky, J., Reid, V., Volein, A., & Johnson, M.H. (2004). Maternal personality and infants' neural and visual responsivity to facial expressions of emotion. *Journal of Child Psychology and Psychiatry, 45*, 1209-1218. doi: 10.1111/j.1469-7610.2004.00320.x

Doan, S.N. (2010). The role of emotion in word learning. *Early Child Development and Care, 180*, 1065-1078. doi: 10.1080/03004430902726479

Fenson, L., Pethick, S., Renda, C., Cox, J.L., Dale, P.S., & Reznick, J.S. (2000). Short form versions of the MacArthur Communicative Development Inventories. *Applied Psycholinguistics, 21*, 95-115.

Fernald, A. (1993). Approval and disapproval: Infant responsiveness to vocal affect in familiar and unfamiliar languages. *Child Development, 64*, 657–674. doi: 10.1111/j.1467-8624.1993.tb02934.x

Fernald, A., & Kuhl, P. (1987). Acoustic determinants of infant preference for motherese speech. *Infant Behavior and Development, 10*, 279-293. doi: 10.1016/0163-6383(87)90017-8

Fernald, A., & Mazzie, C. (1991). Prosody and focus in speech to infants and adults. *Developmental Psychology, 27,* 209-221. doi: http://dx.doi.org/10.1037/0012-1649.27.2.209

Field, T., Diego, M., Hernandez-Reif, M., Schanberg, S., & Kuhn, C. (2003). Depressed mothers who are "good interaction" partners versus those who are withdrawn or intrusive. *Infant Behavior and Development, 26*, 238-252. doi: 10.1016/S0163-6383(03)00020-1

Field, T., Hernandez-Reif, M., Diego, M., Feijo, L., Vera, Y., Gil, K., & Sanders, C. (2007). Still-face and separation effects on depressed mother-infant interactions. *Infant Mental Health Journal, 28*, 314-323. doi: 10.1002/imhj.20138

Field, T., Nadel, J., Hernandez-Reif, M., Diego, M., Vera, Y., Gil, K., & Sanders, C. (2005). Depressed mothers' infants show less negative affect during non-contingent interactions. *Infant Behavior and Development, 28*, 426-430. doi: 10.1016/j.infbeh.2005.03.003

Fish, M., Stifter, C. A., & Belksy J. (1991). Conditions of continuity and discontinuity in infant negative emotionality: Newborn to five months. *Child Development, 62*, 1525-1537. doi: 10.1111/j.1467-8624.1991.tb01623.x

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development, 26*, 64-86. doi: 10.1016/S0163-6383(02)00169-8

Gogate, L.J., Walker-Andrew, A.S., & Bahrick, L.E. (2001). The intersensory origins of word comprehension: An ecological-dynamic systems view. *Developmental Science, 4*, 1-18. doi: 10.1111/1467-7687.00143

Hallgren, K. A. (2012). Computing inter-rater reliability for observational data: An overview and tutorial. *Tutorials in quantitative methods for psychology, 8,* 23-24. doi: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3402032/

Hernandez-Reif, M., Field, T., Diego, M., & Ruddock, M. (2006). Greater arousal and less attentiveness to face/voice stimuli by neonates of depressed mothers on the Brazelton Neonatal Behavioral Assessment Scale. *Infant Behavior and Development, 29,* 594-598. doi: 10.1016/j.infbeh.2006.05.003

Herrera, E., Reissland, N., & Shepherd, J. (2004). Maternal touch and maternal child-directed speech: Effects of depressed mood in the postnatal period. *Journal of Affective Disorders, 81,* 29-39. doi: 10.1016/j.jad.2003.07.001

Hoehl, S., Palumbo, L., Heinisch, C., & Striano, T. (2008). Infants' attention is biased by emotional expressions and eye gaze direction. *Developmental Neuroscience, 19,* 579-582. doi: 10.1097/WNR.0b013e3282f97897

Hollich, G., Hirsh-Pasek, K., & Golinkoff, R.M. (2000). Breaking the language barrier: An emergentist coalition model for the origins of word learning. *Monographs of the Society for Research in Child Development, 65* (3, Serial No. 262). doi: http://www.jstor.org/stable/3181533

Houston-Price, C., & Nakai, S. (2004). Distinguishing novelty and familiarity effects in infant preference procedures. *Infant and Child Development, 13,* 341-348. doi: 10.1002/icd.364

Hunnius, S., de Wit, T.C.J., Vrins, S., & von Hofsten, C. (2011). Facing threat: Infants' and adults' visual scanning of faces with neutral, happy, sad, angry, and fearful emotional expressions. *Cognition and Emotion, 25,* 193-205. doi: 10.1080/15298861003771189

Iverson, J.M., Capirci, O., Longobardi, E., & Casello, M.C. (1999). Gesturing in mother-child interactions. *Cognitive Development, 14*, 57-75. doi: 10.1016/S0885-2014(99)80018-5

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

Kaplan, P. S., Bachorowski, J.A., Smoski, M. J., & Hudenko, W.J. (2002). Infants of depressed mothers, although competent learners, fail to learn in response to their own mothers' infant-directed speech. *Psychological Science, 13*, 268-271. doi: 10.1111/1467-9280.00449

Kaplan, P. S., Bachorowski, J.A., Smoski, M. J., & Zinser, M. C. (2001). Role of clinical diagnosis in effects of maternal depression on infant-directed speech. *Infancy, 2*, 533-544. doi: 10.1207/S15327078IN0204_08

Kaplan, P.S., Bachorowski, J.A., & Zarlengo-Strouse, P. (1999). Child-directed speech produced by mothers with symptoms of depression fails to promote associative learning in 4-month-old infants. *Child Development, 70,* 560-570. doi: 10.1111/1467-8624.00041

Kaplan, P.S., Burgess, A.P., Sliter, J.K., & Moreno, A.J. (2009). Maternal sensitivity and the learning-promoting effects of depressed and nondepressed mothers' infant-directed speech. *Infancy, 14,* 143-161. doi: 10.1080/15250000802706924

Kaplan, P.S., Danko, C.M., Diaz, A., & Kalinka, C.J. (2011). As associative learning deficit in 1-year-old infants of depressed mothers: Role of depression duration. *Infant Behavior and Development, 34,* 35-44. doi: 10.1016/j.infbeh.2010.07.014

Kaplan, P.S., Danko, C.M., Kalinka, C.J., & Cejka, A.M. (2012). A developmental decline in the learning-promoting effects of infant-directed speech for infants of mothers with chronically elevated symptoms of depression. *Infant Behavior and Development, 35*, 369-379. doi: 10.1016/j.infbeh.2012.02.009

Kaplan, P.S., Dungan, J.K., & Zinser, M.C. (2004). Infants of chronically depressed mothers learn in response to male, but not female, infant-directed speech. *Developmental Psychology, 40*, 140-148. doi: http://dx.doi.org/10.1037/0012-1649.40.2.140

Kaplan, P.S., Goldstein, M.H., Huckeby, E.R., & Cooper, R.P. (1995). Habituation, sensitization, and infants' responses to motherese speech. *Developmental Psychology, 28*, 45-57. doi: 10.1002/dev.420280105

Kellough, J.L., Beevers, C.G., Ellis, A.J., & Wells, T.T. (2008). Time course of selective attention in clinically depressed young adults: An eye-tracking study. *Behaviour Research and Therapy, 46*, 1238-1243. doi: 10.1016/j.brat.2008.07.004

Kitamura, C. & Burnham, D. (2003). Pitch and communicative intent in mother's speech: Adjustments for age and sex in the first year. *Infancy, 4*, 85-110. doi: 10.1207/S15327078IN0401_5

Kotsoni, E., de Haan, M., & Johnson, M.H. (2001). Categorical perception of facial expressions by 7-month-old infants. *Perception*, *30*, 1115-1125. doi: 10.1068/p3155

Kroenke K., Spitzer R.L., & Williams, J.B. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*, 606-613. doi: http://dx.doi.org/10.1046%2Fj.1525-1497.2001.016009606.x

Kubicek, L.F., & Emde, R.N. (2012). Emotional expression and language: A longitudinal study of typically developing earlier and later talkers from 15 to 30 months. *Infant Mental Health Journal, 33*, 553-584. doi: 10.1002/imhj.21364

Leppänen, J.M., & Nelson, C.A. (2009). Tuning the developing brain to social signals of emotions. *Nature Reviews Neuroscience, 10*, 37-47. doi: 10.1038/nrn2554

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

Locke, J.L. (2001). First communion: The emergence of vocal relationships. *Social Development*, *10,* 294-308. doi: 10.1111/1467-9507.00167

MacDonald, K. & Parke, R. D. (1984). Bridging the gap: Parent-child play interaction and peer interactive competence. *Child Development, 55*, 1265-1277. doi: http://www.jstor.org/stable/1129996

Mumme, D.L., Fernald, A., & Herrera, C. (1996). Infants' responses to facial and vocal emotional signals in a social referencing paradigm. *Child Development, 67*, 3219- 3237. doi: 10.1111/j.1467-8624.1996.tb01910.x

Murray, L., Marwick, H., & Arteche, A. (2010). Sadness in mothers' 'baby-talk' predicts affective disorder in adolescent offspring. *Infant Behavior and Development, 33*, 361-364. doi: 10.1016/j.infbeh.2010.03.009

Naber, F.B.A., Swinkels, S.H.N., Buitelaar, J.K., Dietz, C., van Daalen, E., Bakermans-Kranenburg, M.J., … van Engeland, H. (2007). Joint attention and attachment in toddlers with autism. *Journal of Abnormal Child Psychology, 35*, 899-911. doi: 10.1007/s00787-007-0648-6

Newman, R. S., & Hussain, I. (2006). Changes in infant preference for infant-directed speech in low and moderate noise by 4.5- to 13-month-olds. *Infancy , 10*, 61–76. doi: 10.1207/s15327078in1001_4

Nicely, P., Tamis-LeMonda, C.S., & Bornstein, M.H. (1999). Mothers' attuned responses to infant affect expressivity promote earlier achievement of language milestones. *Infant Behavior and Development, 22,* 557-568. doi: 10.1016/S0163-6383(00)00023-0

NICHD Early Child Care Research Network. (1999). Chronicity of maternal depressive symptoms, maternal sensitivity, and child functioning at 36 months. *Developmental Psychology, 35,* 1297-1310. doi: http://dx.doi.org/10.1037/0012-1649.35.5.1297

Oakes, L. (2009). The "Humpty Dumpty Problem" in the study of early cognitive development. *Perspectives on Psychological Science, 4,* 352-358. doi: 10.1111/j.1745-6924.2009.01137.x

Peltola, M.J., Leppänen, J.M., Mäki, S., & Hietanen, J.K. (2009). Emergence of enhanced attention to fearful faces between 5 and 7 months of age. *Social Cognitive and Affective Neuroscience (SCAN), 4,* 134-142. doi: 10.1093/scan/nsn046

Peltola, M.J., Leppänen, J.M., Vogel-Farley, V.K., Hietanen, J.K., & Nelson, C.A. (2009). Fearful faces but not fearful eyes alone delay attention disengagement in 7-month-old infants. *Emotion, 9,* 560-565. doi: http://dx.doi.org/10.1037/a0015806

Pilkonis, P. A., Choi, S. W., Reise, S. P., Stover, A. M., Riley, W. T., & Cella, D. (2011). Item banks for measuring emotional distress from the Patient-Reported Outcomes Measurement Information System (PROMIS®): Depression, Anxiety, and Anger. *Assessment*, *18*, 263–283. doi: 10.1177/1073191111411667

PROMIS Health Organization (PHO) and PROMIS Cooperative Group. (2008-2012). Level 2-Anxiety-Adult (PROMIS Emotional Distress-Anxiety-Short Form).

Quevedo, L.A., Silva, R.A., Godoy, R., Jansen, K., Matos, M.B., Taveras Pinheiro, K.A., & Pinheiro, R.T. (2011). The impact of maternal post-partum depression on the language development of children at 12 months. *Child: Care, Health, and Development, 38,* 420-424. doi: 10.1111/j.1365-2214.2011.01251.x

Reissland, N., Shepherd, J., & Herrera, E. (2003). The pitch of maternal voice: A comparison of mothers suffering from depressed mood and non-depressed mothers reading books to their infants. *Journal of Child Psychology and Psychiatry, 44,* 255-261. doi: 10.1111/1469-7610.00118

Rose, S.A., Futterweit, L.R., & Jankowski, J.J. (1999). The relation of affect to attention and learning in infancy. *Child Development, 70,* 549-559. doi: 10.1111/1467-8624.00040

Schafer, G., & Plunkett, K. (1998). Rapid word learning by fifteen-month-olds under tightly controlled conditions. *Child Development, 69,* 309-320. doi: www.jstor.org/stable/1132166

Scherer, K.R. (2003). Vocal communication of emotion: A review of research paradigms. *Speech Communication, 40*, 227-256. doi: 10.1016/S0167-6393(02)00084-5

Schofield, C.A., Johnson, A.L., Inhoff, A.W., & Coles, M.E. (2012). Social anxiety and difficulty disengaging threat: Evidence from eye-tracking. *Cognition and Emotion, 26,* 300-311. doi: 10.1080/02699931.2011.602050

Shapiro, J. R., & Mangelsdorf, S. C. (1993). The determinants of parenting competence in adolescent mothers. *Journal of Youth and Adolescence, 23,* 621-641. doi: 10.1007/BF01537633

Shukla, M., White, K.S., & Aslin, R.N. (2011). Prosody guides the rapid mapping of auditory word forms onto visual objects in 6-mo-old infants. *Proceedings of the National Academy of Sciences, 108*, 6038-6043. doi: 10.1073/pnas.1017617108

Singh, L., Morgan, J.L., & Best, C.T. (2002). Infants' listening preferences: Baby talk or happy talk? *Infancy, 3*, 365-394. doi: 10.1207/S15327078IN0303_5

Smith, P.B., & Pederson, D.R. (1988). Maternal sensitivity and patterns of infant-mother attachment. *Child Development, 59*, 1097-1101. doi: www.jstor.org/stable/1130276

Sohr-Preston, S.L., & Scaramella, L.V. (2006). Implications of timing of maternal depressive symptoms for early cognitive and language development. *Clinical Child and Family Psychology Review, 9*, 65-83. doi: 10.1007/s10567-006-0004-2

Sorce, J.F., Emde, R.N., Campos, J., & Klinnert, M.D. (1985). Maternal emotional signaling: Its effect on the visual cliff behavior of 1-year-olds. *Developmental Psychology, 21*, 195-200. doi: http://dx.doi.org/10.1037/0012-1649.21.1.195

Squires, J.K., Potter, L., Bricker, D.D., & Lamorey, S. (1998). Parent-completed developmental questionnaires: Effectiveness with low and middle income parents. *Early Childhood Research Quarterly, 13*, 345-354. doi: 10.1016/S0885-2006(99)80043-X

Stein, A., Malmberg, L.E., Sylva, K., Barnes, J., Leach, P., & the FCCC team. (2008). The influence of maternal depression, caregiving, and socioeconomic status in the post-natal year on children's language development. *Child: Care, Health, and Development, 34*, 603-612. doi: 10.1111/j.1365-2214.2008.00837.x

Teinonen, T., Aslin, R.N., Alku, P., & Csibra, G. (2008). Visual speech contributes to phonetic learning in 6-month-old infants. *Cognition, 108*, 850-855. doi: 10.1016/j.cognition.2008.05.009

Tobii Technology AB. (2010). Product description: Tobii© Technology: Tobii T/X series eye trackers. *Tobii Technology AB.*

Tompson, M.C., Pierre, C.B., Boger, K.D., McKowen, J.W., Chan, P.T., & Freed, R.D. (2010). Maternal depression, maternal expressed emotion, and youth psychopathology. *Journal of Abnormal Child Psychology, 38,* 105-117. doi: 10.1007/s10802-009-9349-6

Tottenham, N., Tanaka, J.W., Leon, A.C., McCarry, T., Nurse, M., Hare, T.A., …Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168,* 242-249. doi: 10.1016/j.psychres.2008.05.006

Trainor, L.J., Austin, C.M., & Desjardins, R.N. (2000). Is infant-directed speech prosody a result of the vocal expression of emotion? *Psychological Science, 11*, 188-194. doi: 10.1111/1467-9280.00240

Vaish, A., Grossmann, T., & Woodward, A. (2008). Not all emotions are created equal: The negativity bias in social-emotional development. *Psychological Bulletin, 134*, 383-403. doi: http://dx.doi.org/10.1037/0033-2909.134.3.383

Vaish, A., & Striano, T. (2004). Is visual reference necessary? Contributions of facial and vocal cues in 12-month-olds' social referencing behavior. *Developmental Science, 7*, 261-269. doi: 10.1111/j.1467-7687.2004.00344.x

Waxman, S.R., & Gelman, S.A. (2009). Early word-learning entails reference, not merely associations. *Trends in Cognitive Sciences, 13*, 258-263. doi: 10.1016/j.tics.2009.03.006

Weikum, W.M., Oberlander, T.F., Hensch, T.K., & Werker, J.F. (2012). Prenatal exposure to antidepressants and depressed maternal mood alter trajectory of infant speech perception. *Proceedings of the National Academy of Sciences, 109*, 17221-17227. doi: 10.1073/pnas.1121263109

Werker, J.F., Cohen, L.B., Lloyd, V.L., Casasola, M., & Stager, C.L. (1998). Acquisition of word-object associations by 14-month-old infants. *Developmental Psychology, 34*, 1289-1309. doi: http://psycnet.apa.org/doi/10.1037/0012-1649.34.6.1289

Whitehurst, G.J., Falco, F.L., Lonigan, C.J., Fischel, J.E., DeBaryshe, B.D., Valdez-Menchaca, M.C., & Caulfield, M. (1988). Accelerating language development through picture book reading. *Developmental Psychology*, *24*, 552-559. doi: http://dx.doi.org/10.1037/0012-1649.24.4.552

Wu, R., Tummeltshammer, K.S., Gliga, T., & Kirkham, N.Z. (2014). Ostensive signals support learning from novel attention cues during infancy. *Frontiers in Psychology*, *5*(251), 1-9. doi: 10.3389/fpsyg.2014.00251

Young, G.S., Merin, N., Rogers, S.J., & Ozonoff, S. (2009). Gaze behavior and affect at 6 months: Predicting clinical outcomes and language development in typically developing infants and infants at risk for autism. *Developmental Science, 12*, 798-814. doi: 10.1111/j.1467-7687.2009.00833.x

Zlochower, A.J., & Cohn, J.F. (1996). Vocal timing in face-to-face interaction of clinically depressed and nondepressed mothers and their 4-month-old infants. *Infant Behavior and Development, 19*, 371-374. doi: 10.1016/S0163-6383(96)90035-1

Table 1a

Emotion (Happy, Neutral) x AOI (Eye Region, Mouth Region, Target, Non-Target) During Familiarization

Variable	*F (df)*	*p-level*	η_p^2
Percent Fixation Duration			
Emotion	0.26 (1,17)	.62	.02
AOI	7.51 (3,51)	< .001***	.31
Emotion x AOI	1.80 (3,51)	.16	.10
Fixation Count			
Emotion	4.84 (1,17)	.04*	.22
AOI	6.79 (3,51)	.001***	.29
Emotion x AOI	3.91 (3,51)	.01**	.19

* $p < .05$. ** $p \leq .01$. *** $p \leq .001$.

Table 1b

Emotion (Happy, Neutral) x AOI (Eye Region, Mouth Region, Target, Non-Target) in Block 1

Variable	*F (df)*	*p-level*	η_p^2
Percent Fixation Duration			
Emotion	0.13 (1,17)	.72	.01
AOI	8.85 (1,17)	< .001***	*.34*
Emotion x AOI	0.56 (1,17)	.64	.03
Fixation Count			
Emotion	6.18 (1,17)	.02*	.27
AOI	8.55 (3,54)	<.001***	.34
Emotion x AOI	0.70 (3,54)	.56	.04

*** $p \leq .001$.

Table 1c

Emotion (Happy, Neutral) x AOI (Eye Region, Mouth Region, Target, Non-Target) in Block 2

Variable	*F (df)*	*p-level*	η_p^2
Percent Fixation Duration			
Emotion	.24 (1,17)	.63	.01
AOI	5.72 (3,51)	.002**	.25
Emotion x AOI	5.56 (3,51)	.002**	.25
Fixation Count			
Emotion	0.01 (1,17)	.94	< .001
AOI	4.70 (3,51)	.01**	.22
Emotion x AOI	3.96 (3,51)	.01**	.19

** $p \leq .01$.

Table 2a

Emotion (Happy, Neutral) x AOI (Target, Non-Target) in Familiarization Trials

Variable	*F (df)*	*p-level*	η_p^2
Latency			
Emotion	0.44 (1,17)	.52	.03
AOI	40.08 (1,17)	< .001***	.70
Emotion x AOI	0.85 (1,17)	.37	.05

*** $p \leq .001$.

Table 2b

Emotion (Happy, Neutral) x AOI (Target, Non-Target) in Block 1 Familiarization Trials

Variable	*F (df)*	*p-level*	η_p^2
Latency			
Emotion	1.06 (1,17)	.32	.06
AOI	34.88 (1,17)	< .001***	.67
Emotion x AOI	0.07 (1,17)	.79	.004

*** $p \leq .001$.

Table 2c

Emotion (Happy, Neutral) x AOI (Target, Non-Target) in Block 2 Familiarization Trials

Variable	*F (df)*	*p-level*	η_p^2
Latency			
Emotion	0.15 (1,17)	.71	.01
AOI	22.20 (1,17)	< .001***	.57
Emotion x AOI	4.22 (1,17)	.06	.20

*** $p \leq .001$.

Table 3a

Emotion (Happy, Neutral) x Object (Target vs. Non-Target) in Test Trials

Variable	*F (df)*	*p-level*	η_p^2
Percent Fixation Duration			
Emotion	0.52 (1,17)	.48	.03
AOI	4.14 (1,17)	.06	.20
Emotion x AOI	2.76 (1,17)	.12	.14
Fixation Count			
Emotion	1.40 (1,17)	.25	.08
AOI	2.53 (1,17)	.13	.13
Emotion x AOI	0.11 (1,17)	.75	.01
Latency			
Emotion	2.22 (1,17)	.16	.12
AOI	1.46 (1,17)	.24	.08
Emotion x AOI	0.70 (1,17)	.42	.04

Table 3b

Emotion (Happy, Neutral) x Object (Target vs. Novel Non-Target) in Test Trials

Variable	*F (df)*	*p-level*	η_p^2
Percent Fixation Duration			
Emotion	0.03 (1,17)	.88	.001
AOI	4.43 (1,17)	.05*	.21
Emotion x AOI	1.75 (1,17)	.20	.09
Fixation Count			
Emotion	0.15 (1,17)	.70	.01
AOI	4.18 (1,17)	.06	.20
Emotion x AOI	0.14 (1,17)	.72	.01
Latency			
Emotion	1.88 (1,17)	.19	.10
AOI	1.04 (1,17)	.32	.06
Emotion x AOI	0.38 (1,17)	.55	.02

* $p \leq .05$.

Table 3c

Emotion (Happy, Neutral) x Object (Target vs. Familiar Non-Target) in Test Trials

Variable	*F (df)*	*p-level*	η_p^2
Percent Fixation Duration			
Emotion	0.36 (1,17)	.56	.02
AOI	0.42 (1,17)	.53	.02
Emotion x AOI	0.33 (1,17)	.57	.02
Fixation Count			
Emotion	2.98 (1,17)	.10	.15
AOI	0.05 (1,17)	.83	.003
Emotion x AOI	0.59 (1,17)	.45	.03
Latency			
Emotion	1.28 (1,17)	.27	.07
AOI	0.01 (1,17)	.91	.001
Emotion x AOI	0.84 (1,17)	.37	.05

Table 4

Emotion (Emotion 1, Emotion 2) x Viewer (Infant, Parent) ANOVA for Percent Fixation Duration in Emotion Task

	Variable	*F (df)*	*p-level*	η_p^2
Pair 1 Happy-Neutral	Emotion	4.48	.05*	.21
	Viewer	.002	.96	.001
	Emotion x Viewer	4.61	.05*	.21
	Variable	*F (df)*	*p-level*	η_p^2
Pair 2 Happy-Sad	Emotion	1.80 (1,17)	.20	.10
	Viewer	0.01 (1,17)	.94	.001
	Emotion x Viewer	5.93 (1,17)	.03*	.26
	Variable	*F (df)*	*p-level*	η_p^2
Pair 3 Neutral-Sad	Emotion	0.38 (1,17)	.54	.02
	Viewer	0.05 (1,17)	.82	.003
	Emotion x Viewer	5.88 (1,17)	.03*	.26
	Variable	*F (df)*	*p-level*	η_p^2
Pair 4 Happy-Fear	Emotion	0.18 (1,14)	.68	.01
	Viewer	0.61 (1,14)	.45	.04
	Emotion x Viewer	5.38 (1,14)	.04*	.28
	Variable	*F (df)*	*p-level*	η_p^2
Pair 5 Neutral-Fear	Emotion	0.98 (1,13)	.34	.07
	Viewer	5.40 (1,13)	.04*	.29
	Emotion x Viewer	0.04 (1,13)	.85	.003
	Variable	*F (df)*	*p-level*	η_p^2
Pair 6 Sad-Fear	Emotion	6.30 (1,13)	.03*	.33
	Viewer	0.40 (1,13)	.54	.03
	Emotion x Viewer	0.29 (1,13)	.60	.02

* $p \leq .05$.

Table 5a

Intercorrelations with Infant Questionnaires and Percent Fixation Duration on Familiarization Trials

	Happy				Neutral			
	Eyes	Mouth	Target	Non-Target	Eyes	Mouth	Target	Non-Target
IBQ Surgency[a]	.25	-.17	.10	-.16	.10	-.26	.14	-.12
IBQ Negative Affectivity[a]	.64**	-.31	.20	.10	.64**	-.30	-.04	-.11
IBQ Effortful Control[a]	-.004	-.19	.19	.08	.01	-.04	.33	.04
MCDI Receptive[a]	.14	-.27	.23	.42	.05	-.08	.43	.42
MCDI Productive[a]	-.25	.31	-.16	.21	-.28	.46*	-.08	.21
ASQ Personal-Social[a]	-.14	.23	-.49*	-.05	-.23	.20	-.11	.03
ASQ Communication[b]	.04	-.11	.11	.20	.03	.001	.47	.33

Note. [a]$n = 18$. [b]$n = 17$.
*$p < .05$. **$p < .01$.

Table 5b

Intercorrelations with Infant Questionnaires and Percent Fixation Duration on Test Trials

	Happy		Neutral	
	Target	Non-Target	Target	Non-Target
IBQ Surgency[a]	.27	-.14	-.10	.11
IBQ Negative Affectivity[a]	-.42	.15	.004	.05
IBQ Effortful Control[a]	.33	-.46*	-.08	-.13
MCDI Receptive[a]	.37	.26	.14	.35
MCDI Productive[a]	.34	.01	.22	-.05
ASQ Personal-Social[a]	.15	.31	.13	.26
ASQ Communication[b]	.39	.08	.33	-.10

Note. [a]$n = 18$. [b]$n = 17$.
*$p < .05$.

Figure 1a.

Figure 1a. Screenshot from a happy familiarization trial.

Figure 1b.

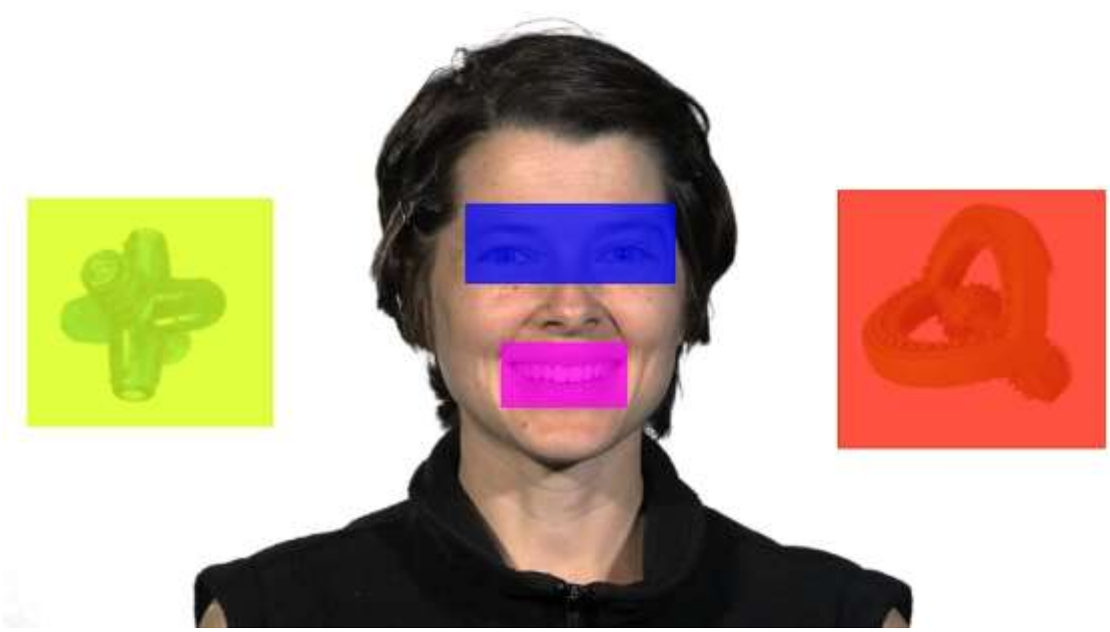

Figure 1b. Example of the AOIs (Eye and Mouth Regions, Familiar Target, Familiar Non-Target) in the happy familiarization trials.

Figure 1c.

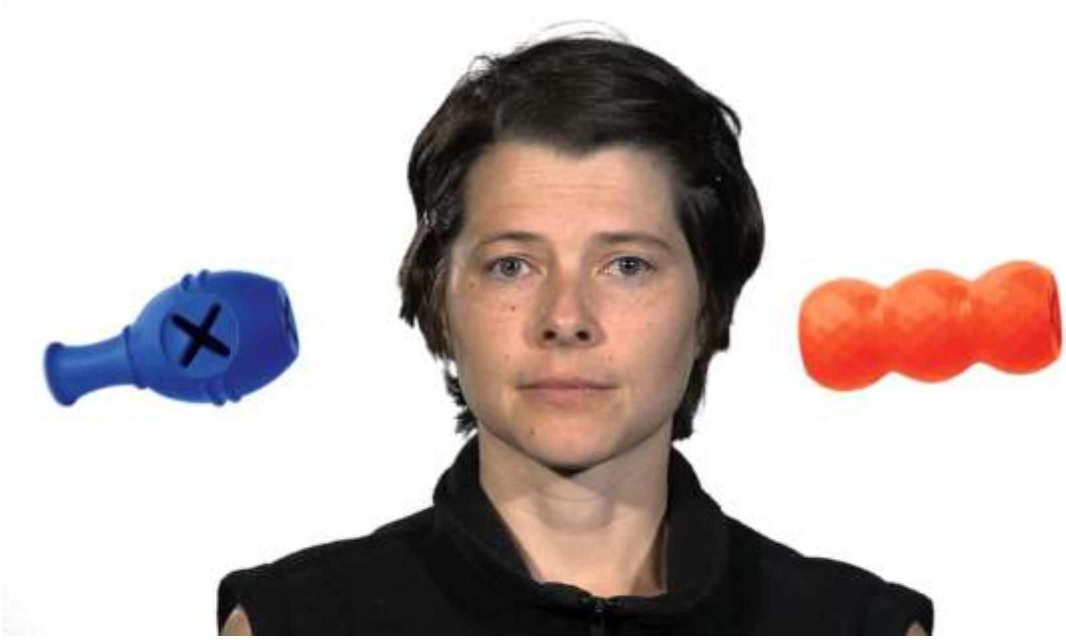

Figure 1c. Screenshot from a neutral familiarization trial.

Figure 1d.

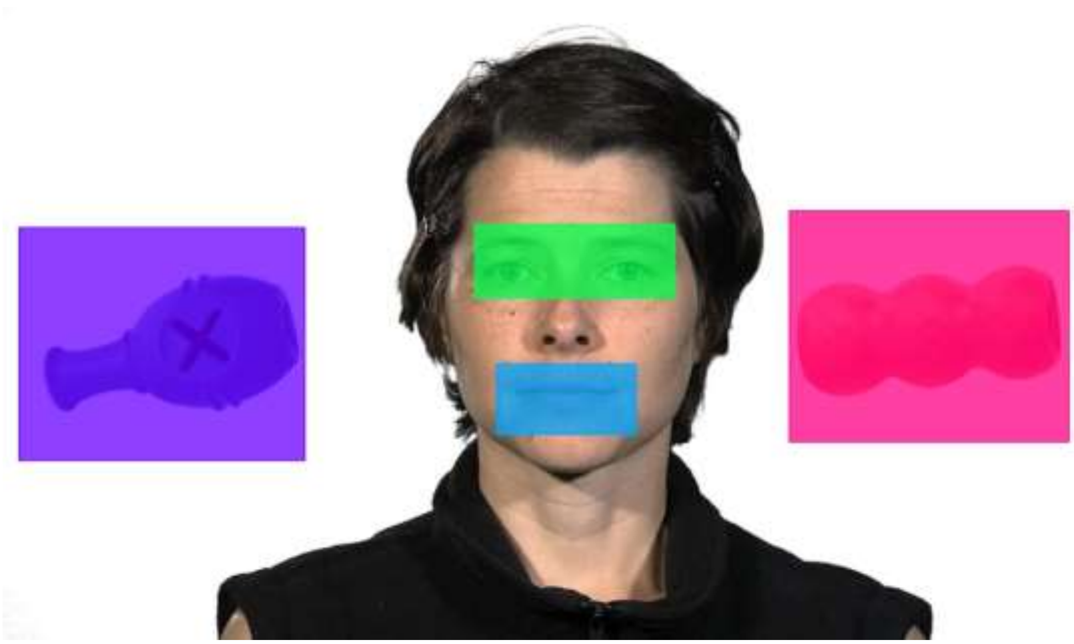

Figure 1d. Example of the AOIs (Eye and Mouth Regions, Familiar Target, Familiar Non-Target) in the neutral familiarization trials.

Figure 2a.

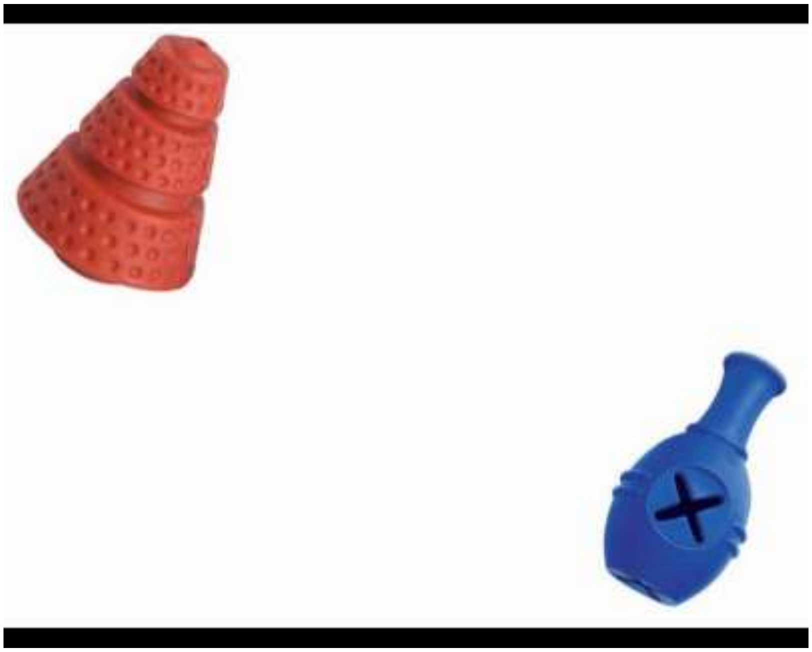

Figure 2a. Example of the familiar non-target test trials during the language task. AOIs for test trials were rectangular boxes drawn around each object.

Figure 2b.

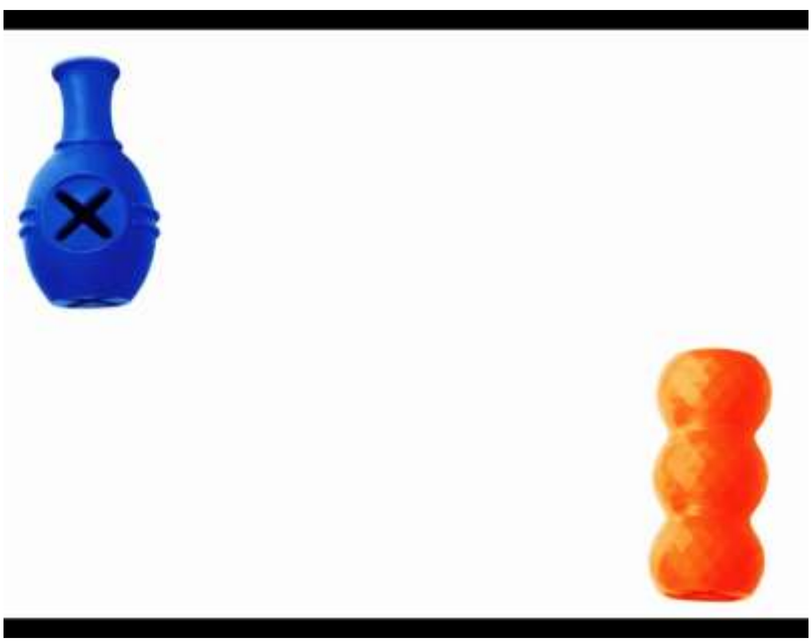

Figure 2b. Example of the familiar non-target test trials during the language task. AOIs for test trials were rectangular boxes drawn around each object.

Figure 3a.

Figure 3a. Example of the face AOIs in the emotion task.

Figure 3b.

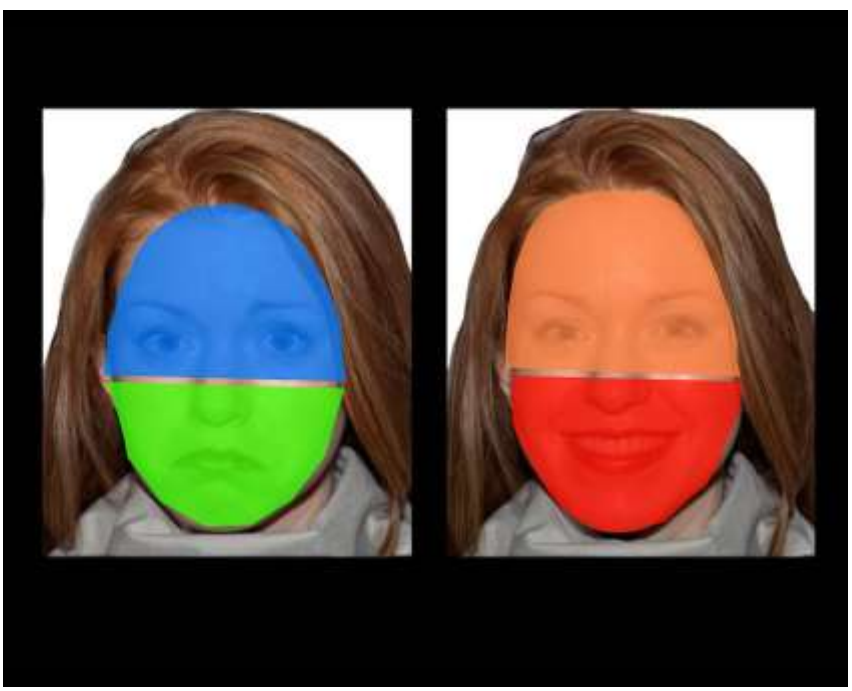

Figure 3b. Example of the AOIs (Eye and Mouth regions) in the emotion task.

Figure 4.

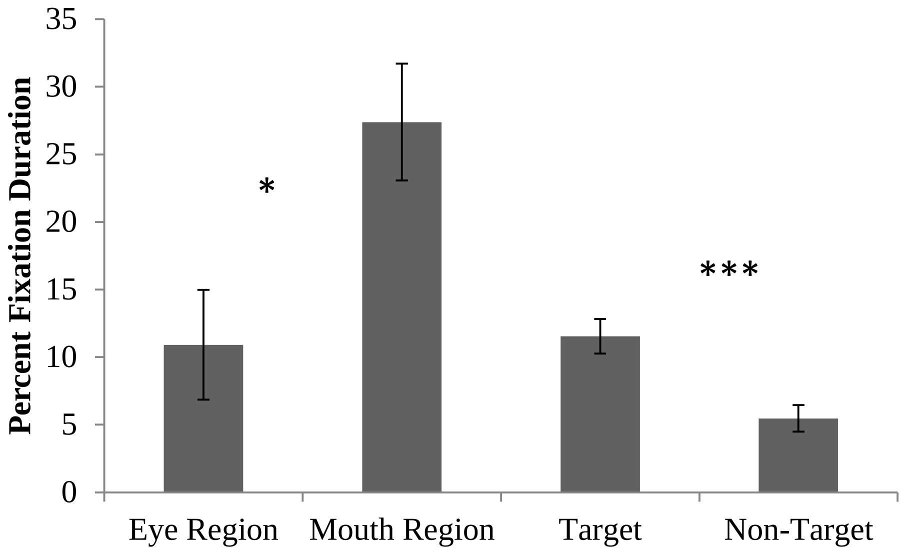

Figure 4. Percent fixation duration for each area of interest (AOI) in the familiarization trials collapsed across emotion. This figure represents the significant main effect of AOI.
* p < .05. *** *p* < .001.

Figure 5.

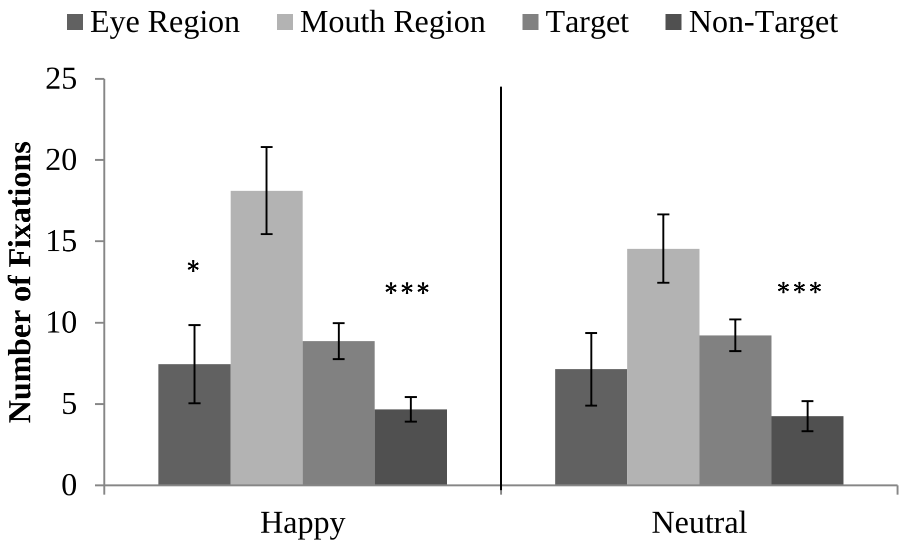

Figure 5. Number of individual fixations to each AOI by Emotion (Happy, Neutral).
* p < .05. *** *p* < .001.

Figure 6.

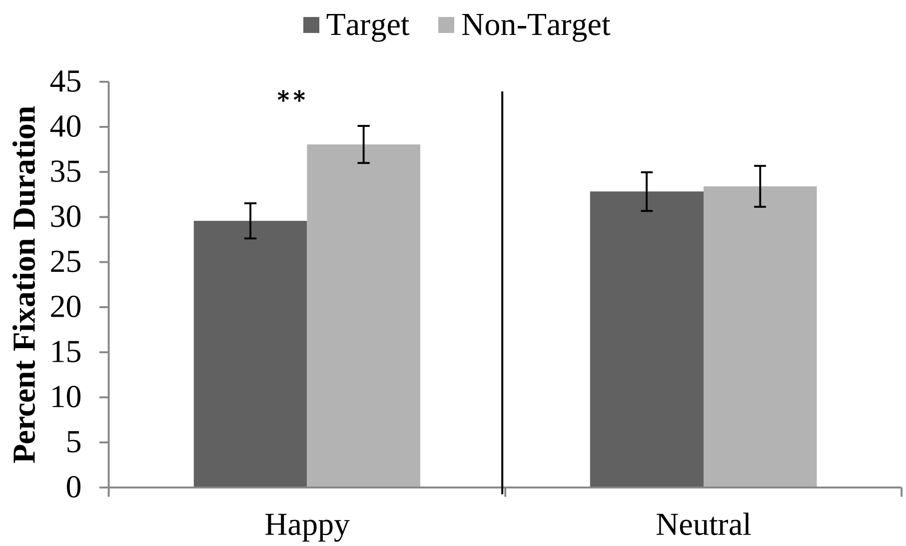

Figure 6. Percent fixation duration to each object (target and non-target) across test trial type. "Non-target" refers to both the novel and familiar non-target objects.
** $p = .01$

Figure 7.

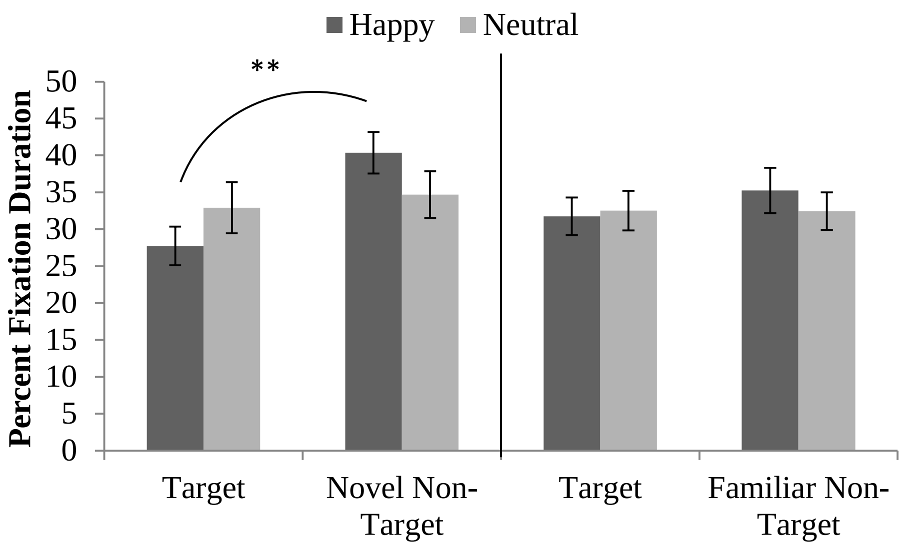

Figure 7. Percent fixation duration to the object AOIs in the two test trial types (novel and familiar non-target).
** $p = .01$.

Figure 8.

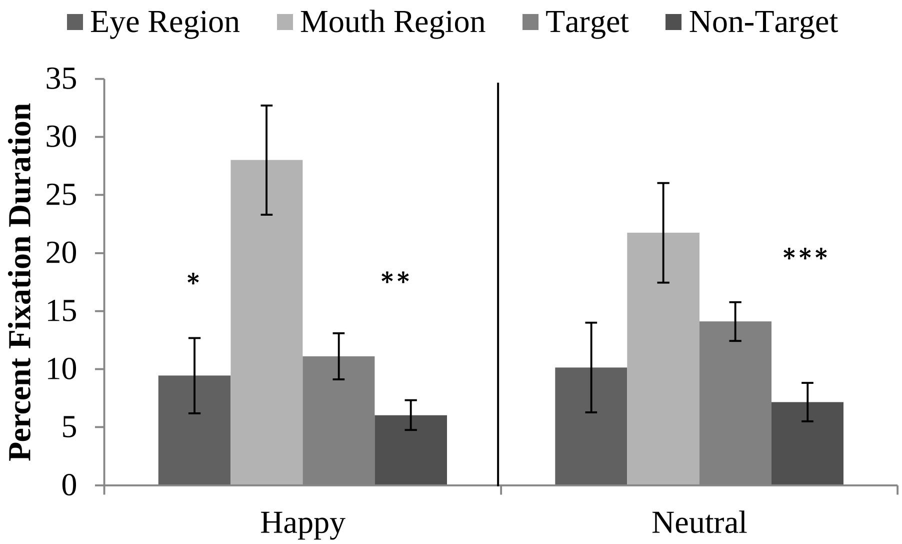

Figure 8. Percent fixation duration to each AOI by Emotion in Block 2 familiarization trials. * p < .05. ** p = .01. *** p < .001.

Figure 9a.

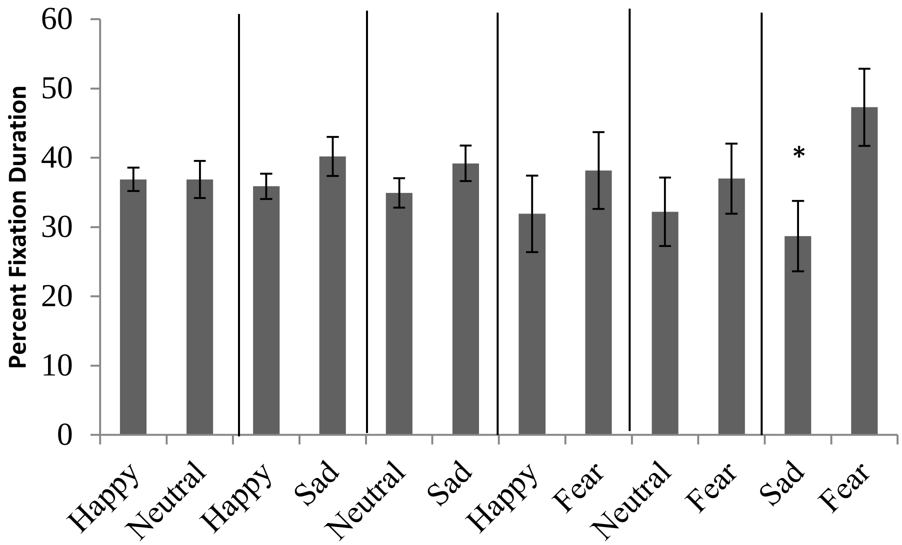

Figure 9a. Infants' percent fixation duration to each face in the emotion pairings. Infants did differentially attend to either face within pairs except in the sad-fear pairing.
* *p* < .05.

Figure 9b.

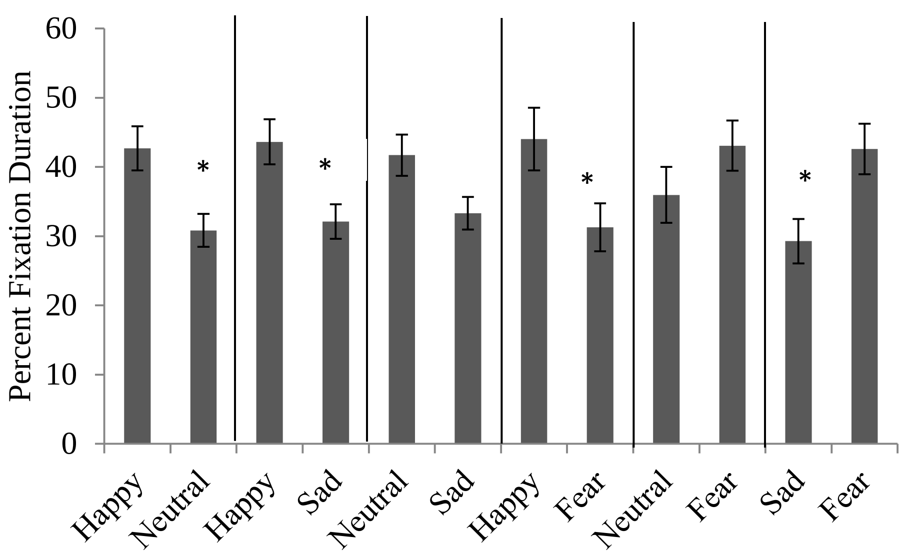

Figure 9b. Adults' percent fixation duration to each face in the emotion pairings.
* *p*s < .05.

Figure 10a.

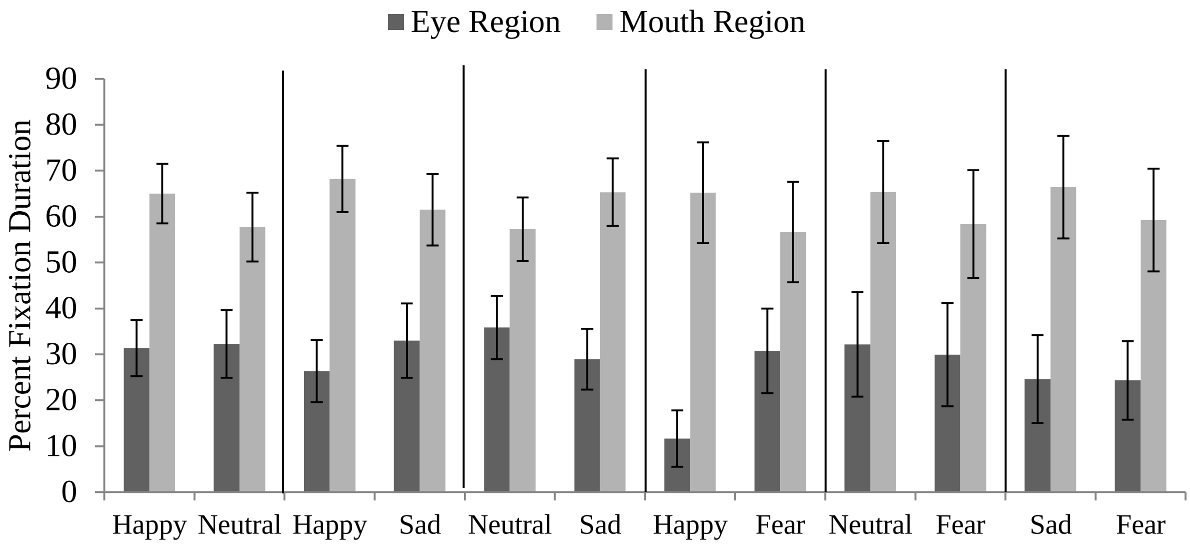

Figure 10a. Infants' percent fixation duration to the eye vs. mouth region AOIs in each emotion pairing. For infants, there was more attention to the mouth region than eye region in all pairs except neutral-fear, where there was no difference between the AOIs.

Figure 10b.

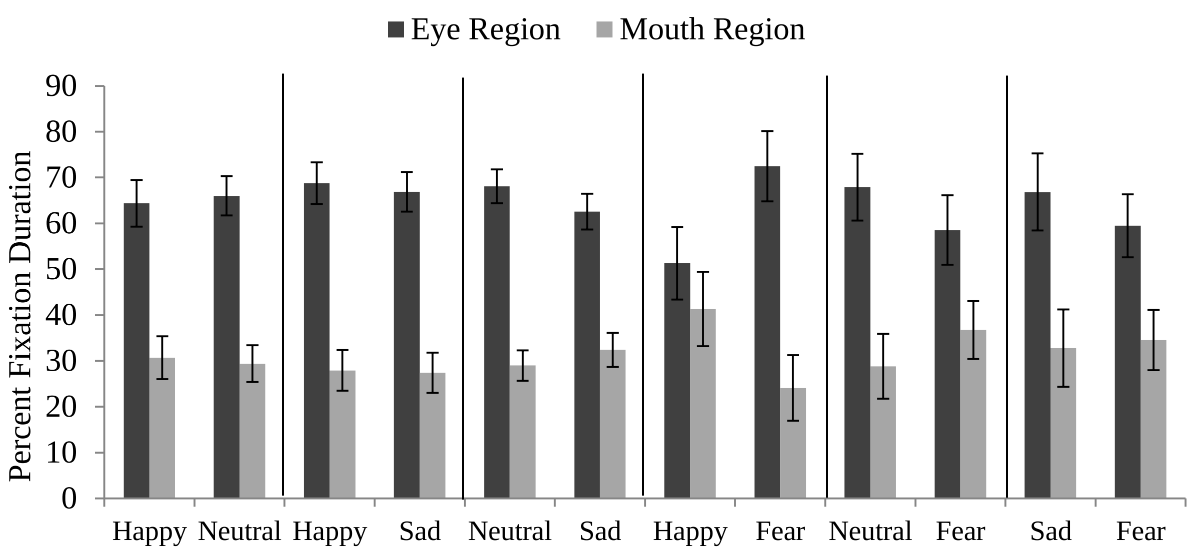

Figure 10b. Adults' percent fixation duration to the eye vs. mouth region AOIs in each emotion pairing. For adults, there was more attention to the eye region than mouth region in all pairs except in happy-fear and sad-fear, where there was no difference between the AOIs.

Appendix A

MacArthur Communicative Development Inventory-Short Form

Fenson, L., Pethick, S., Renda, C., Cox, J.L., Dale, P.S., & Reznick, J.S. (2000). Short form versions of the MacArthur Communicative Development Inventories. *Applied Psycholinguistics*, *21*, 95-115.

Appendix B

Ages and Stages Questionnaire

Ages and Stages Questionnaire (12 month): Communication and Personal-Social scales

Bricker, D., & Squires, J. (1999). Ages and Stages Questionnaires: A parent-completed child-monitoring system. Baltimore, MD: Paul H. Brookes Publishing Co.

Appendix C

Infant Behavior Questionnaire-Revised Very Short Form

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development*, *26*, 64-86. doi: 10.1016/S0163-6383(02)00169-8

Appendix D

Patient Health Questionnaire-9

Severity Measure for Depression – Adult*

*Adapted from the Patient Health Questionnaire – 9 (PHQ-9)

Name: ___________________________ Age: _____ Sex: Male □ Female □ Date: ______________

Instructions: Over the last 7 days, how often have you been bothered by any of the following problems? (Please circle your answer for each item)

						Item Score
		Not at all	**Several days**	**More than half the days**	**Nearly every day**	
1.	Little interest or pleasure in doing things	0	1	2	3	
2.	Feeling down, depressed, or hopeless	0	1	2	3	
3.	Trouble falling or staying asleep, or sleeping too much	0	1	2	3	
4.	Feeling tired or having little energy	0	1	2	3	
5.	Poor appetite or overeating	0	1	2	3	
6.	Feeling bad about yourself – or that you are a failure or have let yourself or your family down	0	1	2	3	
7.	Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3	
8.	Moving or speaking so slowly that other people have noticed? Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3	
9.	Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3	
					Total/Partial Raw Score:	
					Prorated Total Raw Score: (if 1-2 items left unanswered)	

Adapted from Patient Health Questionnaire – 9 (PHQ-9) for research and evaluation purposes

Please circle your answer for the following additional questions:

Have you been diagnosed with depression since your infant was born? Yes No

Do you currently take any medication related to clinical depression? Yes No

Appendix E

Adult PROMIS Emotional Distress – Anxiety – Short Form

Level 2 – Anxiety – Adult*

*PROMIS Emotional Distress – Anxiety – Short Form

Name: ___________________________ Age: _____ Sex: Male □ Female □ Date: _____________

Instructions: Over the last 7 days, how often have you been bothered by any of the following problems? (Please circle your answer for each item)

							Item Score
		Never	**Rarely**	**Sometimes**	**Often**	**Always**	
1.	I felt fearful	1	2	3	4	5	
2.	I felt anxious	1	2	3	4	5	
3.	I felt worried	1	2	3	4	5	
4.	I found it hard to focus on anything other than my anxiety	1	2	3	4	5	
5.	I felt nervous	1	2	3	4	5	
6.	I felt uneasy	1	2	3	4	5	
7.	I felt tense	1	2	3	4	5	
						Total/Partial Raw Score:	
						Prorated Total Raw Score: (if 1-2 items left unanswered)	
						T-Score:	

Appendix F

Demographics Questionnaire

Infant – Language Emotion Attention Perception Laboratory
Confidential Family Information Survey

INFANT INFORMATION

Infant's Birth Month & Year: ______________ Sex: M F Birthweight: _________ lbs __________ozs

Was your infant: Full Term (38-42 weeks) Premature (≤ 37 weeks) Postmature (>42 weeks)

Has the infant ever been diagnosed with a middle ear infection? Yes No How many?_____________

Has your infant had any other medical/developmental problems? Yes No If yes, please describe below:
____
____

What is the primary language spoken to the infant in your home?_______________________________

Please list any other languages that are spoken to the infant in your home: ______________________

FAMILY INFORMATION

Mother's Current Age: ___________________ Father's Current 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: (please circle)	\$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 Cohabitating Single Widowed

Mother's Race: (circle all that apply)	White	Asian
	American Indian/Alaska Native	Native Hawaiian/Pacific Islander
	Hispanic/Latino	Black/African American
Father's Race: (circle all that apply)	White	Asian
	American Indian/Alaska Native	Native Hawaiian/Pacific Islander
	Hispanic/Latino	Black/African American

Are there older children living in your home? Yes No If yes, please list their ages:_________________

Has any child in the family been diagnosed/suspected of hearing impairment? Yes No
If yes, please describe: ____

Has any child in the family been diagnosed/suspected of language impairment? Yes No
If yes, please describe: ____

Has any child in the family been diagnosed/suspected of an autism spectrum disorder? Yes No
If yes, please describe: ____

Appendix G

Language Task Phrases.

Familiarization Trial Phrases

Boog Phrases

1.
- "Hi baby"
- "Did you see the boog?"
- "That's a nice boog."
- "Do you like the boog?"

2.
- "Hi baby"
- "I saw a boog."
- "Did you see the boog?"
- "That's such a great boog."

Neem Phrases

1.
- "Hi baby"
- "That's such a great neem."
- "Did you see the neem?"
- "Do you like the neem?"

2.
- "Hi baby"
- "Did you see the neem?"
- "I saw a neem."
- "That's a nice neem."

Jode Phrases

1.
- "Hi baby"
- "Do you like the jode?"
- "That's such a great jode."
- "Did you see the jode?"

2.
- "Hi baby"
- "That's a nice jode."
- "Did you see the jode?"
- "I saw a jode."

Pake Phrases

1.
- "Hi baby"
- "Do you like the pake?"
- "That's such a great pake."
- "Did you see the pake?"

2.
- "That's a nice pake."
- "Did you see the pake?"
- "I saw a pake."

Test Trial Phrases

Blank Test Trial Prompt Screen
- "Where is the _____?"

Novel and Non-Target Test Trial
- "Can you find the _____?"

Appendix H

Informed Consent

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants in Research Projects Involving Human Subject

Title:
Bidirectional Influence of Emotion Processing on Language Development in Infancy: Evidence from Eye-tracking Mothers and Infants

Principal Investigators:
Robin Panneton, Ph.D. (director)
Alison Heck, M.S.

I. Purpose of this Research/Project
The purpose of this project is to determine the influence emotion plays on language learning during infancy. Additionally, we are interested in how the mother's own emotion style may influence her infant's emotion processing.

II. Procedures
You and your infant will be tested for approximately one hour. For the eye-tracking task, the baby will be placed in a highchair sitting next to you. The infant will face a monitor of an eye-tracking system. All movies will be presented on this screen. First, the infant will see a simple screen with moving dots so that we can calibrate their eye positions. For the first task, the infant will see a series of movie clips of women speaking and looking at objects. The woman on the screen will name one object several times, and then we will test the infant with a screen full of objects to see if he/she can locate the one that is being named.

For the second task, you (the caregiver) will see a series of slides with adult females portraying emotion expressions. On each slide, you will see two expressions by the same adult. We will give you several seconds to simply look at these pictures in any way that you choose. Next, we will present the exact same task to your infant (again, you will be sitting next to your infant while they view these slides). The location and duration of each eye movement that you and your infant produce during this entire sequence are recorded by the eye-tracker.

Next, we will videotape you and your infant playing together with a variety of toys for approximately 10 minutes. We are interested in natural interactions between mothers and their infants, and no specific instructions will be given.

If for any reason, your infant cries or falls asleep during any task, testing will be discontinued.

In addition, you will be asked to complete several questionnaires. The PHQ-9 will be completed during the appointment. The remaining material will be sent home with you in a packet to be mailed back in the included self-addressed stamped envelope.

III. Risks
There are no apparent risks to your infant or to yourself for participation in this study. Sound levels for all auditory stimuli will be verified prior to the testing of each adult and infant. All sound tracks are kept at 68 dB SPL at the head of the listener. This is the sound level of normal conversational speech.

IV. Benefits
Although there are no direct benefits to the participants in this study, all parents will receive a summary report of the results of this project (a general analysis of the patterns of looking across all of the infants). Additionally, all parents will be provided a list of mental health resources in the area. Parents will also receive a certificate of appreciation and the results of the study will contribute to a broader body of research on infant social attention and language learning.

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. However, the results of this project may be used for scientific and/or educational purposes, presented at scientific meetings, and/or published in a scientific journal.

VI. Compensation
All participants will earn $10 in cash regardless of study completion.

VII. Freedom to Withdraw
You have the right to terminate your or your infant's involvement at any point in time and for any reason should you chose to do so.

VIII. Participant's Responsibilities
I voluntarily agree to have my infant participate in this study. I voluntarily agree to participate in this study.

IX. Participant's Permission
I have been given an opportunity to ask further questions about this procedure and I understand that I have the right to end this session for any reason if I so choose. This project has been approved by the Human Subjects Committee of the Department of Psychology and the Institutional Review Board of Virginia Tech. If I have any questions regarding this research and its conduct, I should contact one of the persons named below. Given these procedures and conditions, I give my permission to Dr. Panneton, Ms. Heck and their co-workers to test my son/daughter.

I hereby acknowledge the above and give my voluntary consent for my infant to participate in this study.

Infant's Name: ____

Signature of Parent: ____

Date: ____

I hereby acknowledge the above and give my voluntary consent to participate in this study.

Parent Printed Name: ____

Signature of Parent: ____

Date: ____

I would like to be contacted by phone regarding future studies: YES NO

Dr. Robin Panneton, Principal Investigator 231-5938
Alison Heck, Graduate Student and Co-Investigator 231-3972

Dr. David Harrison, Chair, Human Subjects Committee	231-4422
David M. Moore, DVM, Assistant Vice Provost for Research Compliance	231-4991

Appendix I

Mental Health Resources.

Below is a list of agencies and facilities that offer a variety of mental health services

24 Hour Crisis Hotlines

- **RAFT Crisis Hotline/ACCESS –** A service of New River Valley Community Services: Emergency services clinicians are available to meet with you at your location. A friend or family member can call for you if you feel that you are unable to do so yourself. Call 540-961-8400; www.nrvcs.org/services.htm#Access:_Emergency_&_Assessment_Services,_Adult_Clinical_Services

- **CONNECT** – A 24-hour referral and emergency evaluation service of Carilion Health Care. Call 1-800-284-8898 or 540-731-7385; www.carilionclinic.org/psych/connect-evaluations

- **RESPOND** – A mental health admittance and referral service of Montgomery Regional Hospital and Lewis Gale Hospital. Call 540-953-5324; lewisgale.com/service/mental-health

- **Domestic Violence Hotline –** A service of the Women's Resource Center: 540-639-1123 or 1-800-788-1123 (toll free)

Emergency Shelter

- **Women's Resource Center –** 540-639-1123 or 1-800-788-1123 (toll free); www.wrcnrv.org

Individual or Group Counseling

- **Virginia Tech Psychological Services Center –** A community-based training facility run by Virginia Tech offering assessment and counseling: 540-231-6914; www.psyc.vt.edu/outreach/psc

- **Virginia Tech Cook Counseling Center** – A mental health provider for Virginia Tech students: 540-231-6557; www.ucc.vt.edu/contact_us/index.html

- **Women's Resource Center –** A free private, non-profit provider offering counseling and support groups for victims of sexual abuse and domestic violence: 540-639-1123 or 1-800-788-1123 (toll free); www.wrcnrv.org

- **Mental Health Association –** A private, non-profit mental health organization: 540-951-4990 or 1-800-559-2800 (toll free); www.mhanrv.org/

- **New River Valley Community Services** – A public, non-profit provider of behavioral health services: 540-961-8300; www.nrvcs.org/

- **Free Clinic of the NRV** – A provider of behavioral health services: 540-381-0820; www.nrvfreeclinic.org/pro-bono-counseling.html

- **Anxiety and OCD Support Group –** Last Tuesday of each month at 7:00 pm; Virginia Tech Psychological Services Center, Blacksburg; Contact: 540-231-6914; http://www.psyc.vt.edu/outreach/psc

- **Depression and Bipolar Peer Support Group –** 3rd Tuesday of each month at 6:30 ~ 8:00 pm; Mental Health America of New River Valley, Blacksburg;
Contact: ddonaldson@mhanrv.org or 540-951-4990; http://mhanrv.org/contact-us/

Appendix J

Maternal Sensitivity Task Coding

Adapted from Fish, Belsky, & Stifter (1991); Shapiro & Mangelsdorf (1994); Calkins, Hungerford, & Dedmon (2004); MacDonald & Park (1984); with input from Cindy Smith and her lab's coding schemes and changes from Robin Panneton and her graduate students (Spring 2015).

Epoch: 30 sec

Facilitates Attention

To what extent and how skillfully did mother facilitate the infant's response to the object through such behavior as positioning the infant so that he/she can see the object and is comfortable; drawing the infant's attention to the object verbally ("See the keys?") or by pointing at or tapping it.

1. Very low; little (if any) facilitation, or behavior that doesn't help the infant focus on the target.
2. Low to moderate. There may be a few brief instances of facilitative behavior based on infant's behavior, but mother is not really directing infant's attention.
3. Fairly high; most of the mother's facilitative behavior is appropriate; there are a few brief instances of mother not helping infant focus.
4. Very high; mother exhibits appropriate and facilitative behaviors and seems especially turned in to her infant (e.g., refocuses the infant's attention when he/she loses interest).

Demonstrates Contingency

To what extent did the mother respond directly to the infant's behavior; issuing either verbal or physical responses to something the infant did in a timely manner (Infant looks at rattles, and mother says "You like those rattles, don't you?"; Infant knocks down blocks and laughs, mother says "Did you like knocking those blocks down?")

1. Very low; mother does not respond to what the infant is doing, either in her own behavior and/or in her vocalizations.
2. Low to moderate; mother occasionally responds to what the infant is doing, but in a poorly timed way (e.g., interrupts the infant's activity by responding too quickly or "misses" the infant's activity by not responding quickly enough).
3. Fairly high; mother is often responding to infant's activity but either timing is not sensitive or she is inconsistent in whether she acts or speaks to infant based on what infant is doing.
4. Very high; mother consistently responds to infant's behavior in a timely manner. Very tuned into what the infant is currently doing.

Intrusiveness

To what extent does the mother display intrusive, over-controlling behavior? Does the mother address her own agenda and ignore or override the infant's preferences, such that the child's behavior is redirected. Does the mother fail to moderate her behavior after infant shows disinterest or aversion to her? Does she offer a barrage of toys without gauging infant's interest? Take away toys infant is still observing? Intrusively grab the infant's face to direct his/her attention?

1. Very low; mother shows little to no instances of intrusive or over-controlling behaviors.
2. Low to moderate; mother may show a few instances of intrusive or over-controlling behavior but more often than not, the mother is not intrusive or over-controlling.
3. Fairly high; mother mixes intrusive and over-controlling behavior with short periods of non-intrusive or non-controlling behavior.
4. Very high; mother is consistently intrusive or over-controlling; constantly redirects the child's behavior or attention, without regard for the current focus of the infant's attention. Mother engages in activity (whether physical, verbal, or both) to a level that seems to make the infant uncomfortable.

Maternal Positive Affect

To what extent does the mother convey positive emotion to the infant, either in her mannerisms, her voice, or both? Does she consistently engage the infant with a positive tone in her voice? Does she smile, laugh, and nod in a positive way when responding to the infant's behavior?

1. Very low; Little to no positive affect; mother expresses no positive emotion when communicating with child either in; mother's emotional expression was neutral or negative
2. Low to moderate; intensity positive; slight or very brief smile.
3. Fairly high; clear smile or prolonged slight smiles; uses prolonged positive tone.
4. Very high; intense smile or laugh, or smiling for more prolonged period; uses positive tone throughout episode.

NOTE--- for the above variables, ratings are summed across epochs and then divided by the number of epochs to get a mean value.

Maternal Engagement

Number of epochs in which the mother was actively participating in the child's activity as opposed to merely observing the activity

Utterances

Lexical: how many words did the mother say in an epoch?

Nonlexical: how many non-word utterances did the mother make during an epoch (e.g., "shh", "uh huh", etc.)?

Gestural-M: how many gestures did the mother produce in an epoch (e.g., pointing)

Gestural-I: how many gestures did the infant produce in an epoch (e.g., pointing)

Time Stamp (s)	Epoch	Fac. Attention (1-4)	Intrusiveness (1-4)	Positive Affect (1-4)	Engagement (Y/N)	Lexical Utterances (#)	Non lexical Utterances (#)	Gestures-M (#)	Gestures-I (#)
0:00-0:30	1								
0:30-1:00	2								
1:00-1:30	3								
1:30-2:00	4								
2:00-2:30	5								
2:30-3:00	6								
3:00-3:30	7								
3:30-4:00	8								
4:00-4:30	9								
4:30-5:00	10								
5:00-5:30	11								
5:30-6:00	12								
6:00-6:30	13								
6:30-7:00	14								
7:00-7:30	15								
7:30-8:00	16								
8:00-8:30	17								
8:30-9:00	18								
9:00-9:30	19								

9:30-10:00	20								
	Total								
	Total/ #epochs								