Effects of Facial and Vocal Emotion on Word Recognition

in 11-to-13-Month-Old Infants

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(ABSTRACT)

The speech commonly addressed to infants (infant-directed speech or IDS) is believed to have multiple functions, including communication of emotion and highlighting linguistic aspects of speech. However, these two functions are most often studied separately so that the influence of emotional prosody (the changes in intonation and vocal quality that relate to emotion) on linguistic processing in infants has rarely been addressed. Given that language learning during infancy occurs in the context of natural infant-caretaker exchanges that most certainly include emotion communication and co-regulation, it is important to integrate the concepts of emotional communication and linguistic communication in studying language learning. This study examined the influence of both positive (happy) and negative (sad) face+voice contexts on word recognition in 11-to-13-month-old infants. It was hypothesized that infants would learn and subsequently recognize words when they were delivered in a happy context, but will experience more difficulty in learning and/or recognition of the same words when delivered in a sad context. The general pattern of results confirmed these predictions in that after habituating to sentences containing a specific target nonsense word, infants in the Happy Condition recovered their attention to the same sentences with a novel target word. In contrast, infants in the Sad Condition showed no significant recovery to a change in target words. These results contribute to our understanding of how emotional tone can facilitate and/or attenuate attention in older infants as they engage in language learning with their caretakers.

Dedication

To Daddy and Mummy for their love, support and absolute confidence in me. Daddy, thank you for instilling the love of books and reading. For your hard work, patience and humor. Mummy, thank you for all your prayers, encouragement and optimism. I could have never made it without both of you.

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Introduction

One of the dominant hypotheses about language development involves the convergence of emotion, cognition and social interconnectedness (Bloom, 1993, 1997). Language would never be acquired without engagement in a world of persons, objects and events. Two primary categories of information that get communicated to infants throughout their first postnatal year are: (1) indexical, involving information that promotes recognition of caregivers (e.g., vocal signatures); and (2) affective, involving information that allows the infant to interpret the caregiver's behavior (e.g., positive emotion in the face and voice). Even though the bulk of research on communicative development has involved infants' perception of the linguistic aspects of speech (e.g., phoneme discrimination, word recognition), the indexical and affective qualities of voice might be equally, if not more important to the infant, and are often ignored (Reddy, 1999).

Speech in the everyday environment of a young infant is rarely bereft of emotion. Several researchers (e.g. Locke, 1993; Trainor, Austin, & Desjardins, 2000) believe that emotions provide the initial perceptual pull for the acquisition of language in that infants are primarily drawn towards speech because of its emotional tone. Because one of the main accomplishments of the first postnatal year is lexical growth, it is reasonable to assume that vocal and facial emotion (especially positive affect) might be essential aspects of the language learning process. In fact, word learning is intimately connected to an infant's emotional life and language acquisition takes place when a child is engaged in

dynamic real-life events with feelings and thoughts about other persons. However, the role of emotion in the acquisition of spoken language has received little empirical attention. The current study addressed the issue of whether communicative affect impacts infants' attention to language by examining the influence of both positive and negative emotion, as expressed in a bimodal context (face + voice), on word learning and recognition in 11-month-old infants. Emotion information in both the face and the voice was considered because of the general importance of multimodal information on infants' perceptual learning (Bahrick & Lickliter, 2000), and because communication is a multisensory event involving redundancy of information across visual and auditory domains (Gogate & Bahrick, 1998; Gogate, Bahrick & Watson, 2000).

Characteristics of adults' speech to infants

The speech that caregivers typically use when interacting with infants is known as infant-directed speech (IDS). Perhaps the most prominent characterization of IDS has to do with its exaggerated prosodic form especially when compared to typical adult-directed speech (ADS). The word 'prosody' comes from the Greek word *prosoidia*, meaning a song sung with accompaniment where the song is composed of words and its melody and the musical accompaniment. Prosody is an integral determinant of spoken language and is often defined in physical terms, basically involving acoustic parameters of pitch, duration and intensity. Prosody serves to convey not only linguistic information but also paralinguistic (intentional, stylistic) and non-linguistic information (including age, gender, physical and emotional states of the speaker; Fujisaki, 1997).

IDS is exaggerated in both its vocal prosody and facial prosody (Gogate, Bahrick & Watson, 2000), and infants learn language by listening as well as looking at caretakers'

voices, mouth movements, smiles, facial movements and accompanying body movements (e.g., head-nodding). In fact, ID facial expressions are more exaggerated, slower in tempo and longer in duration than adult-directed facial expressions. Importantly infants discriminate ID and AD facial expressions highlighting the contrast between the two speech registers visually (Chong, Werker, Russell & Carroll, 2003).

Additionally, IDS has distinct acoustic characteristics such as higher pitch (fundamental frequency or F_0), more exaggerated pitch contours, larger pitch range (the difference between F_0 maximum and minimum), slower tempo, longer pauses and more rhythmic contours than ADS (Fernald, 1991; Katz, Cohn & Moore, 1996; Trehub, Trainor & Unyk, 1993). Multiple functions have been attributed to the prosody in IDS (Fernald, 1993). Besides directing and maintaining attention (Fernald, 1991; Cooper & Aslin, 1990) and aiding language learning by exaggerating lexical and grammatical structure (e.g. simplified phrasal structure and redundancy cues; Fernald & Mazzie, 1991; Kelmer Nelson et al., 1989), communication of intent and emotion through vocal and facial expressions is another proposed function (Fernald, 1991; Papousek, 1992). The prosodic patterns of IDS appear to convey more accurate information than ADS about the communicative intent of speakers even for adults (Fernald, 1989). Specific pitch contours are associated with different communicative contexts in IDS (Papousek, Papousek, & Symmes, 1991). Expression of approval and elicitation of attention are associated with large bell-shaped contours. Soothing is associated with lower-pitched, falling contours and prohibiting behavior with short-lower pitched, flat contours.

Hence, IDS is prevalent in infants' daily environment across several cultures and languages (Fernald, Taeschner, Dunn, Papousek, Boysson-Bardies, & Fukui 1989;

Papousek & Hwang, 1991) with a few exceptions (Ratner & Pye, 1984, which have been deemed controversial; see Monnot, 1999 for further discussion). IDS prosody is probably influencing infants' emotional and linguistic processing in multiple ways, especially given that infants prefer IDS to ADS at different ages (Cooper, Abraham, Berman, & Staska, 1997; Cooper & Aslin, 1990; Fernald, 1993; Werker & McLeod, 1989). The influence of emotional and linguistic prosody on the perception of auditory and audio-visual speech will be discussed in detail before elaborating on the purpose of the current study.

The Role of Prosody in Speech Perception

Prosodic information is initially more salient than phonetic information for language comprehension (Fernald, 1989) and there is some evidence that prosodic features are mastered by infants and toddlers long before their articulation of full grammatical strings (e.g. Snow, 1994). Prosody can fulfill many different functions with the most well-known distinction being between its cuing of emotional states (emotional or affective prosody) and language structure (linguistic prosody).

Emotional prosody

The emotional or affective function involves transmission of information by the prosodic features with respect to the speaker's emotional state concerning the context of an utterance (Merewether & Alpert, 1990; Scherer, 2003). It is hypothesized that exaggerated IDS prosody might result primarily from the vocal expression of emotion and that other probable functions of IDS (e.g., attention elicitation and exaggeration of linguistic components) take advantage of this primary function of emotional engagement (Kitamura & Burnham, 1998; Singh, Morgan & Best, 2000; Trainor, Austin &

Desjardins, 2000). There is some support for this hypothesis. Comparison of the acoustic characteristics of IDS and emotional ADS reveal remarkable similarity. Infants prefer positive vocal affect at least through the first half of the first year (Kitamura & Burnham, 1998; Singh et al, 2002). For example, infants show no preference for either IDS or ADS when the affect is equated, suggesting that previous demonstrations of preferences for IDS over ADS were confounded by differences in emotional valence (Kitamura & Burnham, 1998; Singh et al., 2002). Further when ADS consists of more positive affect than IDS, infants prefer ADS. This finding is similar to Kitamura and Burnham's (1998) who found that 6-month-old infants preferred high affect IDS to low affect IDS when the average pitch was equated and found no preferences for high pitch IDS over low pitch IDS when affect was held constant. Infants' preference for happy talk or IDS is believed to capture their attention towards the language patterns in their native language and ultimately help them acquire linguistic skills (Singh, et al., 2002).

The emotional prosody in speech also seems to influence infants' production in addition to their perception. In one study, 5-month-old-English-learning infants were exposed to audio samples of unfamiliar women uttering approvals and prohibitions (both in IDS and ADS) in German, Italian, Japanese or English; the infants responded with more positive affect to approvals and more negative affect to prohibitions in all conditions except for Japanese IDS prosody and English ADS prosody (Fernald, 1993). Likewise, 5- and 7-9-month-old infants showed greater affective responsiveness to the vocal features of IDS compared to ADS (Werker & McLeod, 1989).

Interestingly, the acoustic features most commonly examined in detail with IDS (pitch, loudness and duration) have been independently studied with expression of

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emotions in speech. In spite of interspeaker variability in adults (Frick, 1985; Murray & Arnott, 1993), gross changes in pitch seem to contribute most to the transmission of emotions, with utterance duration being next in emotional significance, and loudness (or amplitude) being the least emotionally relevant. Importantly, the specific acoustic characteristics most associated with IDS are its exaggerated pitch and pitch range, and duration (Fernald & Kuhl, 1987) with intensity/loudness playing a relatively restricted role. Pitch and pitch range have been proposed as being fundamental to infants' perception of prosody (Fernald & Kuhl, 1987; Plantinga & Trainor, 2005; Trainor & Desjardins, 2002).

More recently, the role of utterance duration in emotional speech has also been investigated with infants. Both 1.5- and 4-month-old infants attend more to slow IDS than normal duration IDS when pitch characteristics are equivalent (Panneton, McIlreavy, Cooper, Ostroff, & Aslin, 2006). In contrast, older infants (8-month-olds) attend equally to normal or slow versions of IDS utterances, suggesting that as infants become more familiarized with speech, duration alone is less salient as a cue to emotional valence. Moreover, younger infants (4.5-month-olds) attend more to slow- compared to normal- IDS when both utterances have been judged as being high in positive affect but attend more to IDS utterances judged high in affect (compared to others judged to be lower in affect) when duration is held constant (Panneton, Kitamura, Mattock & Burnham, 2006). Thus the combination of exaggerated pitch and exaggerated duration affect infants' perception of emotional tone in speech, especially at younger ages. This is consistent with adult studies which find that slow speech with high pitch is often perceived to be happy whereas slow speech with low pitch is perceived to be sad (Banse & Scherer,

1996). Interestingly, older infants (8-month-olds) in the Panneton et al. study (2006) showed greater attention for the normal duration of the utterances but surprisingly no differential attention for the high and low affect IDS when it was of a slower duration. Older infants' lack of preference for high affect IDS is also reflected in characteristics of mothers' IDS to infants near the end of the first postnatal year.

In addition to infants' changing preferences for certain acoustic characteristics at different ages, their mothers' IDS characteristics also have been reported to change across infant age. Mothers' IDS to their infants at birth, 3, 6, 9 and 12 months of age was contrasted for different acoustic features including mean pitch, pitch range and their relationship with the measures of communicative intent, expressing affect, comforting or soothing, encouraging attention, directing behavior and positive affect (Kitamura & Burnham, 2003). Mean pitch was found to be related to affective type utterances (positive affect, encouraging attention, express affection and comfort or soothe) and pitch range with directive utterances (encouraging attention and directing behavior). Also, mothers use more comforting and soothing utterances with very young infants, but this abates by 3 months of age as the pitch, pitch range and the other four measures of communicative intent increases (i.e., mothers start to encourage attention more as the infant gets older).   Positive emotion, expressing affection, encouraging attention and comforting and soothing features peak around 6 months of age, perhaps resulting from more mother-initiated interactions (Cohn & Tronick, 1987) and infants expressing greater interest (Malatesta, Grigoreyev, Lamb, Allin & Culver, 1986).

Around 9 months of age, mothers' IDS shows a decline in mean pitch and affective features, but increases in pitch range and use of directive utterances. The

decrease in emotion in IDS at this age has been attributed to the possible need for greater processing of speech without the distraction of exaggerated emotional characteristics of IDS (Kitamura & Burnham, 2003; Lacerda, Sundberg, Andersson, & Alex, 1995). At 12 months of age, mothers' IDS showed a resurgent increase in emotion, which could be attributed to them offering more encouragement and reward to their infants as language production burgeons.

The significance of positive emotion in IDS input for infants' speech perception and subsequent language acquisition is demonstrated when some infants are not provided with the same affect in IDS in their daily interactions. This scenario is evident in interactions between depressed parents and their infants. Depression affects different facets of interpersonal communication, including rate of speech (Teasdale, Fogarty, & Williams, 1980), eye-to-eye contact (Bellack, Hersen, & Himmelhoch, 1983), voice quality (Breznitz, 1992; Scherer, 1986) and emotional expressiveness (Berenbaum & Ollmanns, 1992; Sloan, Strauss, & Wisner, 2001). All of the above-mentioned characteristics encompass emotional communication and impairment in communication that may lead to deficits in language learning. Importantly, 4-month-old infants of chronically depressed mothers do not learn to associate their mother's IDS or an unfamiliar depressed mother's IDS with a smiling face, but they do learn this association with non-depressed females' voices (Kaplan, Dungan & Zinser, 2004; Kaplan, Bachorowski, & Zarlengo-Strauss, 1999). However infants at slightly older ages (e.g., 9- to 12-month-olds) who have clinically depressed mothers failed to make the association even with non-depressed females' voices, but did learn to associate non-depressed fathers' and non-depressed male IDS to a smiling face. It was proposed that infants of

depressed mothers learn to ignore their mothers' negative tone, but then generalize this even to non-depressed females with extended experience, possibly hindering language learning. At least one study has found that children with depressed mothers show reduced language productivity (Breznitz & Sherman, 1987; Nicely, Tamis-LeModa & Bornstein, 1999). Evidence from depression and language development possibly reveals the influence of negative emotion (especially sad affect) on acquisition of language and therefore needs further evaluation.

Overall, emotional vocal prosody has been extensively examined with infants in the form of IDS. Despite the multiple roles assigned to the prosody in IDS, emotion seems to provide the initial perceptual pull for infants' attention, with other functions (linguistic highlighting) subsequently latching onto this primary function. In the adult literature, emotional tone of voice has been known to influence processing of lexically ambiguous words (Nygaard & Lunders, 2002), and recognition memory is enhanced for words with emotional content compared to relatively neutral words in adults (Dietrich, Emrich, Johannes, Wieringa, Waller & Munte, 2000). So how does vocal prosody bootstrap linguistic processing in infants?

Linguistic prosody

Prosody is believed to play a vital role in acquisition of language. The prosodic bootstrapping hypothesis links linguistic prosody to language learning. This hypothesis states that the prosodic information provides useful and important cues for the infant about the syntactic structure of language (Fisher & Tokura, 1996; Gleitman, Gleitman, Landau, & Wanner, 1988; Morgan, 1996). A few examples of these cues are pausing, syllable lengthening, and intonation contours. The three major aspects of this hypothesis

are: (1) syntax is reliably correlated with acoustic properties, (2) infants are sensitive to these properties and, (3) infants use these acoustic cues in the processing of speech.

Prosodic bootstrapping plays a vital role even in adult speech processing (especially in English) where intonational emphasis is used to accent novel information (Chafe, 1974; Gerken, 1996; Halliday, 1967). Boundaries of both sentences and restrictive relative clauses in English are marked by falling pitch contours and final vowel lengthening (Cooper & Sorensen, 1981; Garro & Parker, 1982). Importantly, words conveying new information are highlighted by higher pitch and longer duration relative to words conveying old information (Brown, 1983; Eady & Cooper, 1986). Stressed words are processed more rapidly and judged to be more intelligible by adult listeners (Fowler & Housum, 1987). Interestingly, the exaggerated prosodic features of IDS also assist *adults'* learning of a foreign language compared to the same language in ADS (Golinkoff & Alito, 1995).

It is believed that the exaggerated prosody in IDS might be helping infants to segment the sound stream and identify the linguistic units within continuous speech. These linguistic units include phonemes, words, clauses and sentences (Morgan, 1996; O' Shaughnessy, 1979). Infants have demonstrated high levels of sensitivity to prosodic information in speech input discriminating different languages based on rhythmic, durational and intonational characteristics of the signal (Jusczyk, Frederici, Wessels, Svenkerud, & Jusczyk, 1993; Nazzi, Bertoncini & Mehler, 1998). For example, infants learning English are better able to identify target lexical items from the speech stream containing the dominant strong-weak stress pattern of the English language than when they contained a weak-strong stress pattern (Jusczyk & Aslin, 1995). Considerable

evidence shows that infants take advantage of the facilitating property of prosody in segmenting speech input (Jusczyk, Cutler, & Redanz, 1993; Morgan & Saffran, 1995; Newsome & Jusczyk, 1994) and in grammatical categorization (Chafetz, 1994; Shady & Gerken, 1999).

Exaggerated pitch contours alone facilitated vowel discrimination in 6 to 7-month-olds (Trainor & Desjardins, 2002). Primary caregivers also exaggerate formant frequencies of ID compared to AD vowels (/i/, /a/ and /u/), which differentiate these vowels categories (Kuhl, Andruski, Chistovich, Chistovich, Kozhevnikova, Ryskina, Stolyarova, Sundberg, & Lacerda, 1997). This expanded vowel space has been recently observed in naturalistic Norwegian IDS as well (Englund & Behne, 2005). This exaggeration in vowel space is also known as hyperarticulation, and it has been observed that talkers with larger vowel spaces were more intelligible than talkers with reduced spaces (Bradlow, Torretta, & Pisoni, 1996). Hence mothers' hyperarticulation of vowels in IDS might be making speech more intelligible for the infant and possibly aiding them in word recognition. An interesting recent study compared infant-directed speech and pet-directed speech with respect to features like pitch, affect and hyperarticulation of vowels of mothers' speech while talking to their 6 month-old infants, adults and pet dogs or cats (Burnham, Kitamura & Vollmer-Conna, 2002). Affect and pitch were equivalent in IDS and pet directed speech. However, only IDS contained hyperarticulated vowels. It was proposed that mothers might be exaggerating their vowels for infants but not pets because they intuitively perceive the didactic functions IDS might serve. To test the utility of hyperarticulation, maternal speech clarity was assessed by examining the vowel space of IDS in English and Mandarin and measuring its correlation with the speech

discrimination skills of 6-8 and 10-12 month-old infants (Liu, Kuhl, & Tsao, 2003). A significant positive correlation was demonstrated between maternal speech clarity and infant speech perception performance in both age groups.

In addition to hyperarticulation, caregivers also modify their words in certain ways to facilitate comprehension. Mothers increase the duration of content-words in IDS (Albin & Echols, 1996). There is a high rate of repetition and redundancy in IDS which might aid learning (Fernald & Morikawa, 1993; Fisher & Tokura, 1996; Steedman, 1996; Venditti, Jun, & Beckman, 1996). Prosodic features used to highlight individual words in IDS and ADS were compared in a study (Fernald & Mazzie, 1991). Mothers were recorded telling a story to a 14-month-old infant and an adult, using a picture book with six target items as focus of attention. These authors found that mothers were more likely to place the focused target words in utterance-final position in IDS than in ADS. Focused words were more often stressed, and occurred on F_0 peaks in IDS than with ADS. Infants recognize and segment utterance-final words more successfully (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998).

Beyond words, analyses of IDS reveal exaggerated phrase- and clause-level structure (Fernald & Mazzie, 1991; Kemler Nelson, Hirsh-Pasek, Jusczyk, & Cassidy, 1989). Infants are sensitive to clause boundaries in IDS but not in ADS (Kelmer-Nelson et al., 1989). Jusczyk, Hirsh-Pasek, Kelmer-Nelson, Kennedy, Woodward, and Piwoz (1989) showed that 9- but not 6-month-old infants preferred to listen to sentences in which pauses were located at phrase boundaries rather than at locations within the phrases. Even though this preference was seen in both IDS and ADS, IDS seemed to enhance the preference since the discrimination was made more easily.

Thus, vocal prosody plays a crucial role in both communication of affect and linguistic processing for infants. Prosody has been extensively studied in the auditory domain with infants but not comprehensively in other domains (mainly visual). This disparity across sensory systems might partially be due to the finding that infants' auditory modality develops before their visual modality (Aslin, 1987; Gottlieb, 1971), but also because prosody is more often operationalized vocally but not visually. Visual prosody and its role in speech perception have a longer history in the adult literature, and have only recently been evaluated in infants and children. Importantly, for a typically developing infant, faces and voices are available simultaneously in their everyday interactions, making it more ecologically valid to investigate the relevance of prosody in each of these two domains. The following section focuses on the integration of prosodic information in faces and voices and its emotional and linguistic impact.

The Role of Prosody in Auditory/Visual Speech Development

In the adult speech perception literature, it is becoming more common to refer to *visual prosody* when considering how information (including emotional intent) is conveyed in both faces and voices (e.g. Somasundaram & Parent, 2005). These two domains (facial and vocal) are brought together in naturalistic parent-infant interaction during IDS (i.e., for sighted and hearing infants). Even though vocal prosody provides cues about boundaries between linguistic units and other information about the structure of language, it is not always reliable (Fisher & Tokura, 1996). Prosody in the visual domain might be providing extra informational support for linguistic processing for typically developing infants. Moreover, visual prosody is significant for the population

of hearing-impaired infants and caregivers, with findings from this literature illustrating the unique interaction of emotion and language in face and hand gestures.

Deaf caregivers using ASL (American Sign Language) with their children use facial expressions (in addition to hand gestures) for signaling both affective and grammatical morphology for the linguistic structures of a language (Reilly & Bellugi, 1996). One study examined the competition between affect and language in ASL IDS, which is similar to vocal IDS in that it is slower, more repetitive and consists of shorter sentences (Reilly & Bellugi, 1996). It was found that mothers of deaf infants constrained linguistic information to hands and affect to faces in their first year of their infants' lives. And importantly, mothers favored affective uses of facial expressions often sacrificing the grammar of motherese (e.g. questions like 'what', 'where' and 'how' addressed in ASL involve grammatically obligatory furrowed brows in ADS but in IDS, adults asked the same questions with a neutral face and used face to convey primarily affect not grammar). As the children reached their second birthday, mothers started including grammatical markers on their faces and IDS became more fully grammatical.

As demonstrated in the example above with deaf infants and caregivers, audio-visual speech is a rich source of information both linguistically and paralinguistically. As noted by Raffler-Engel (1978), within the context of mother-infant interaction, language is accompanied by a variety of other communicative events provided by posture, gestures and facial expressions. Therefore, the emotional and linguistic relevance of audiovisual (AV) speech should be evident in infants' language learning.

Emotional prosody in AV speech

Emotional information can be conveyed by different modes of communication such as speech intonation, propositional content, facial expressions, and gestures. Interestingly, the position of the face and body can affect the spectral structure of speech (e.g., smiling increases the frequency of speech formants; Tartter, 1980; Tartter & Braun, 1994); listeners can often 'hear' a smile. Moreover, facial expressions and intonation have been found to be highly correlated (Borod, Koff, Lorch & Nicholas, 1985; Tartter & Braun, 1994).

The intermodal preference technique (Spelke, 1976) has been used to ask whether infants recognize emotional expressions and involves testing infants' ability to detect correspondence between information available in vision and audition. In this procedure, infants are presented with two concurrent visual displays accompanied by a single sound track corresponding to one of the visual displays. Infants' looking times are measured across trials with increased looking time during matching of vocal and facial expressions indicating recognition. These matching experiments have further provided evidence that older infants (5 to 7 months of age) match happy faces with happy voices and sad faces with sad voices (Walker-Andrews, 1988; Walker-Andrews & Lennon, 1991). Interestingly, 2-month-old infants looked at happy expressions in the same experiment regardless of the sounds they heard, possibly demonstrating an early preference for positive facial expressions. Clearly, there is a developmental progression in the recognition of emotions in the audio-visual domain together. But it is important to realize that all of these studies were carried out with unfamiliar persons expressing different emotions. When the event was their own mother in this intermodal matching procedure, it

was found that infants recognized emotions even at 3 and 3.5 months (Kahana-Kalman & Walker-Andrews, 2001; Montague & Walker-Andrews, 2002; Walker-Andrews, 1998).

The still-face (SF) paradigm also measures recognition of affective expressions by infants. In this SF paradigm, mothers are instructed after a period of active engagement to display a still face and remain unresponsive in an otherwise typical interaction. Infants, as young as 3 months old, show grimacing and negative reactions in response to this situation (Ellsworth, Muir & Hains, 1993; Mayes & Carter, 1990). In one longitudinal study (Izard, Fantauzzo, Castle, Haynes, Rayias, & Putnam, 1995), 2.5, 3, 4.5, 6, 9, and 9.5 month-old infants were observed during mother-infant interactions. In the positive conditions, mothers expressed joy and interest facially and vocally, and in the negative conditions mothers assumed a still face or expressed sadness or anger facially or vocally. The positive conditions elicited more interest and positive expressions and the negative conditions elicited more negative expressions at all ages; also, there was an age-related increase in infant-mother expression matching. Walker-Andrews and Lennon (1991) compared 5-month-old infants' responsiveness to different visual displays with different emotional expressions. When the visual display was a facial expression slide, the infants could easily discriminate between happy, angry, and sad vocal expressions regardless of whether they affectively matched the habituated voice, the novel voice, or neither. But when the visual display was a checkerboard, infants did not discriminate between the vocal expressions of emotion, which is surprising since even younger infants distinguish between voices differing in pitch and other acoustic features (Cooper & Aslin, 1994). The authors proposed that the face might be responsible for greater attention for the affective quality of voices. This seems to be a plausible interpretation considering the

fact that an infant encounters faces and voices together in his or her everyday environment.

It has been proposed that infants first recognize the affective expressions of others as a unified multimodal event; faces, voices, touch and smell are typically experienced together (Walker-Andrews, 1997). Infants learn to subsequently differentiate the auditory and visual modes of specification (Maurer, 1993) and detect unimodal information that potentially specifies meaning of an emotional expression. Hence, recognition of emotions first occurs in a multimodal context and the critical information specifying an emotion occurs in the overall dynamic flow in the facial musculature, voice and body (Ekman & Friesen, 1978; Fogel, 1993). For infants, naturalistic, dynamic and multimodal presentation of emotional expressions might be the optimal events for testing infants' recognition and discrimination (Walker-Andrews, 1997). This is supported by the finding that infants' auditory, visual and haptic systems are well coordinated early in their lives (Burnham, 1993; Gusella, Muir & Tronick, 1988; Walker-Andrews & Lennon, 1991). These findings imply that the multimodal context might be the best situation to assess the responsiveness of infants' perception of the emotion in IDS.

Research on 'social referencing' in the second half-year of life shows that infants detect emotional signals of others through facial and vocal expressions (Klinnert, Campos, Sorce, Emde, & Svedja, 1983). The 8-month-old infants in this study looked at their mother when they were undecided about the visual cliff or approaching an ambiguous toy; the infants approached the toy or cliff when their mothers expressed exaggerated positive affect, but withdraw when their mothers showed negative affect.

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Like vocal prosody, visual prosody appears to afford infants rich information about the emotional experiences and intentions of others, and infants are able to perceive and act on AV emotion information. Does visual prosody also offer information about the structure of infants' native language?

Linguistic prosody in AV speech

The term 'visual speech' refers to the head and facial movements associated with speech production (Graf, Cosatto, Strom & Huang, 2002). There is ample evidence for the positive role of visual speech in adults' perception of language, especially lipreading. Lip reading is a powerful example of AV information in speech perception. Lip reading improves speech intelligibility, especially in noise when AV perception is compared with A-only perception. Moreover, listeners experience speech sounds to be 'louder' when they look at the speaker while listening, compared to when they listen alone (Schwartz, Berthommier, & Savariaux, 2004). Visual lip movements provide salient cues for word recognition (Bernstein, Demorest, & Tucker, 2000), and the presence of facial information increases comprehension of speech signals, especially a heavy foreign accent (Reisberg, McLean & Goldfield, 1987). However, it is not just lip and mouth movements which provide linguistic information. Facial movements such as raising eyebrows and head movements such as nodding also provide essential cues for linguistic and emotional processing (Berger, Garner & Sudman, 1971; Munhall, Jones, Callan, Kuratate, & Vatikiotis-Bateson, 2004; Summerfield, 1979; Yehia, Rubin, & Vatikiotis-Bateson, 1998).   Visual prosody even aids spoken word recognition in Japanese adults, although vision is believed to play a limited role in Japanese speech perception (Munhall et al., 2004). Also, several studies show that use of head and eye brow movement can

determine which word in a sentence is receiving emphatic stress (Bernstein, Eberhardt, & Demorest, 1998) and to discriminate statements from questions (Bernstein et al., 1998; Nicholson, Baum, Cuddy, & Munhall, 2002; Srinivasan & Massaro, 2002).

The McGurk effect is an excellent illustration of the critical link between facial movement and vocal perception, in which the auditory speech syllable [ba] dubbed onto the lip movements for [ga] is perceived as [da] or [tha] by adults and children (MacDonald & McGurk, 1978; McGurk & MacDonald, 1976). The most striking aspect of McGurk effect is that the perceivers are completely unaware that the information seen is different from the information heard unless they look away (Locke, 1993). Recently, 4.5 month-old infants have demonstrated the McGurk effect in a habituation test paradigm supporting the claim that infants can integrate auditory and visual speech information (Burnham & Dodd, 2004). However, there is some evidence that infants do not always integrate information available in the auditory and visual modality as well as the adults during McGurk Effect (Desjardins & Werker, 2004).

Exaggerated head and eye movements have also been associated with IDS and labeled as 'motionese' with infants (Brand, Baldwin, & Ashburn, 2002). Infants as young as 4-months-olds have been found to be sensitive to audiovisual synchrony in a bimodal speech display (Lewkowicz, 1992). Interestingly, infants' face scanning development has been linked to the trajectory of language development as their fixations to the mouth area increases when the lips are moving when they are 6 months old and becoming aware of the speech sounds in their environment (Hunnius & Geuze, 2004). Younger infants fixate significantly more on the eyes than the lips of their caregivers possibly paralleling social and emotional bond formation (Haith, Bergman & Moore, 1977).

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The advantage of faces and voices in IDS prosody was illustrated in an experiment testing 4-, 6- and 8-month-old infants' discrimination of phonemes by first familiarizing them with an adult face uttering a phoneme either in an infant-directed or an adult-directed manner (Lewkowicz, 2000). Then the infants' discrimination of either the change in phoneme (vocal alone), the speaker (facial alone) or both (facial and vocal) was tested. If the speaker in the familiarization phase used only IDS, infants at all ages discriminated all the changes but not when the presentations were in ADS style. With ADS, 4-month-old infants did not discriminate the facial changes illustrating the enhancement of infants' perception of faces by IDS. Also, in another study with younger infants (newborn and 3-month-old infants), it was found that these infants matched vowel sounds with their appropriate mouth movements but only when spoken in an IDS style (Patterson & Werker, 2002, 2003). These studies demonstrate the power of exaggerated IDS register in assisting infants at different ages in both auditory and visual domains.

Overall, both visual and acoustic prosody seem to work in conjunction to provide multiple cues for infants about emotional and linguistic processing. It is important to discuss the interaction of emotional and linguistic prosody and ultimately its influence on word recognition and subsequently language acquisition. As mentioned before, the prosodic bootstrapping hypothesis links prosody as one of the useful cues available for both infants and adults for language acquisition. Even though there is considerable support for the role of prosody in language acquisition (e.g. Morgan & Demuth, 1996), there is not enough evidence to show that prosody is a sufficient explanation for language learning.

<u>Purpose of the Current Study</u>

The primary question of interest for the present study was whether emotional prosody influences linguistic processing in infants. Infants' ability to process prosody at both emotional and linguistic level has rarely been studied together. In fact, only one study to date has investigated the role of speech affect on spoken word recognition (Singh, Morgan, & White, 2004). In this study, 7.5-month-old and 10.5-month-old infants were first familiarized with words either spoken in a happy context or a neutral context and then their recognition of words in fluent passages was tested. Contrary to the authors' prediction that positive affect would facilitate word recognition, younger infants recognized familiar words only when affect was matched across familiarization and testing. Older infants, on the other hand, recognized words across variations in affect when the task was somewhat simplified. Subsequently, it was concluded that early listening preferences do not necessarily predict processing advantages. Interestingly, unlike the younger group of infants, the older group was not influenced by the affect in spoken words as they recognized words irrespective of the affect in the testing phase. This developmental change has been attributed to greater focus by the older infants on the phonemic properties of speech and reduced attention to the emotional prosody. However, one potential shortcoming of this study is that infants were both familiarized and tested with auditory-only presentations (no faces) so that visual prosody was eliminated from their perception.

The present study compared the role of bimodally-specified happy and sad affect on 11-to-13-month-old infants' word recognition by examining infants' processing of words in sentences under different emotional contexts. Infants were presented nonsense

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words in sentences instead of isolated words. There is some evidence that suggests that IDS does not reliably provide isolated words (Aslin, Woodward, LaMendola, & Bever, 1996) and a recent study reveals that infants show faster word recognition in sentence frames than in isolation (Fernald & Hurtado, 2006). Therefore, nonsense words in normal carrier sentences were used as the target speech events to test word recognition in infants.

In the current study, infants' word recognition was tested in a happy and a sad emotional context. Different groups of 11-to-13-month-olds were first presented with a digital movie recording of a female speaker (all IDS) saying a sentence with a nonsense word in a certain emotion tone; with some infants receiving positive emotion events (positive or 'happy' emotion in both face and voice) whereas others received negative emotion events (negative or 'sad' emotion in both face and voice). After the infants habituated to the sentences, they were tested with the same carrier sentences in the same emotional condition, but with a novel nonsense target word.

It was hypothesized that positive (happy) speech would facilitate infants' recognition of words because of the ability of positive affect to support learning, whereas negative (sad) speech would attenuate word recognition because negative affect does not support learning. This differential effect of emotion on learning was predicted because positive emotion attracts infants' attention (helping them process linguistic information). On the other hand, negative emotion (especially sad emotion) would not increase infants' attention to the same extent so that word learning would be compromised.

In order to determine word recognition, an infant-controlled habituation/dishabituation procedure was employed. The major assumption of this paradigm is that infants' habituation to a particular event implies the formation of a

memory for information within that event (Miller, 1983). There is a tendency among all animals to decrease reactivity to a repeated stimulus as they habituate and to reactivate interest (i.e., dishabituate) when the event changes. This procedure is useful with non-verbal infants as it capitalizes on what they can easily do- look at visual events and look away. Habituation/dishabituation has been used extensively to study infant visual, auditory and audio-visual perception (e.g. Colombo, Frick & Gorman, 1997; Lewkowicz, 2003)

Maternal measures of general mood state and emotional expressiveness were also included to further elucidate the relationship between word recognition in infants and maternal emotion. Maternal affect has been linked to infant emotion and cognition such that maternal depression and anxiety has been associated with compromises in mother-infant interaction as well as infants' social and emotional functioning (Weinberg & Tronick, 1998). Infants of mothers with post-partum depression have been found to be less cognitively competent as well as displaying more negative affect than infants with non-depressed mothers (Field, Healy, Goldstein, Perry, Bendell, Schanberg, Zimmerman, & Kuhn, 1988; Whiffen & Gotlib, 1989). Depressed mothers' speech typically consists of more negative affect (Murray, Kempon, Woolgar, & Hooper, 1993) and infants of depressed mothers show failure in an associative learning task that involves the pairing of IDS with a smiling female face (Kaplan, Dungar & Zinser, 2004). The infants of clinically depressed mothers also show delayed language productivity (Nicely, Tamis-LeModa & Bornstein, 1999). Even though this study did not target depressed mothers and their infants specifically, the possible influence of maternal affect (both experienced and expressed) on infants' word recognition was gauged using two maternal self reports.

Ultimately, the important question was whether mother's emotional experience and expression was related to infants' word recognition in happy or sad emotional contexts.

Method

Participants

Thirty-eight 11-to-13-month-old infants were recruited from the developmental science database in the Department of Psychology. The parents of the infants were first sent an invitation letter (see Appendix A) and then received a follow-up phone call. Infants were tested within a week (before or after) of their 11-to-13-month birth date. Three infants were excluded from the final analysis due to inattention and crying, for a final sample size of 35. Mean age of the participants was 11 months ($\underline{SD}$ = 0.89) and 12 days ($\underline{SD}$ = 8.02). The average age of the infants' mothers was $\underline{M}$ = 30.74, $\underline{SD}$ = 5.95. There were 21 males and 14 females in this study. The demographics of the final sample were as follows: 77 % Caucasian, 11.4% biracial, 5.7% Asian American, 2.8% African-American and 2.8% Hispanic. The average years of mothers' education was 15.87 ($\underline{SD}$ = 1.98). 57.08% of this sample had a family income greater than $50,000 and 42.85% had a family income less than $50,000.

Apparatus

Infants were seated on their parent's lap in front of a black panel (5'8" tall x 3'9" wide) containing a 17" flat screen computer monitor (Dell Pentium Computer; Model: DHM), two speakers located immediately adjacent to each side of the monitor (Sony model, SRS-88PC), and a web camera (Logitech Quickcam) placed 6 inches above the monitor. The web camera projected the infants onto the observer computer (Dell Pentium computer; Model: DHM) located in an adjacent room, which the observer used to judge

the infants' looking behavior and subsequently control the session. A Dell Pentium computer (Model: DHM) was used to administer the custom software program for the infant-controlled, testing procedure. The computer controlled the presentation of the events, recording the length of each trial. The sound level for all auditory events was held constant across infants and presented between 65-70 decibels (A scale), as measured at the head of the infant prior to each session (sound level meter description). However, there was no sound available in the control room in which the observer sat during the session in order to keep the observer deaf to the experimental sequence.

AV Movies

Recordings were made of a Caucasian female (who is the mother of a 2-year-old) saying prescripted sentences that each contained a target nonsense word ('neem' or 'boog'). She produced these carrier sentences multiple times in an infant-directed speaking style, but with different emotion valences. She was asked to portray happiness for half of the productions, and sadness for the other half of the productions. The actual content of the sentences supported these different emotional valences. For example, she was recorded saying "This is the sweetest NEEM that I have ever seen!" (Happy) and "He lost his best BOOG today." (Sad). This resulted in 12 sentences, 6 of which contained happy content, and the other 6 contained sad content. Then, 45 undergraduate students rated each of these 12 sentences for their emotional valence on a scale from 0 to 10, with 0 indicating very sad and 10 very happy. From these ratings, 4 sentences were selected for use in the experiment: 2 Happy ($\underline{M}$=8.5; $\underline{SD}$= .42) and 2 sad ($\underline{M}$=1.6; $\underline{SD}$= .31; see Appendix B).

Acoustic characteristics of the happy and sad AV movies

The acoustics of the speech recordings were analyzed with the help of PRAAT software. Independent sample tests revealed significant differences between the pitch, pitch range and intensity of both happy and sad target words in all of the sentences (see Table 1). Two of the primary acoustic correlates of vocal affect are mean F_0 and F_0 range (Banse & Scherer, 1996). The mean F_0 of happy words was significantly higher than that of the sad words, $\underline{t}$ (14) = 3.95, $\underline{p}$ < .001. The mean F_0 range of happy words was also significantly higher than that of the sad words, $\underline{t}$ (14) = 4.70, $\underline{p}$ < .0001. The mean intensity (i.e., loudness) of happy words was significantly greater than sad words, $\underline{t}$ (14) = 7.14, $\underline{p}$ < .0001. However, there was no significant difference in the relative duration between happy and sad words. These findings were similar to the acoustic profile of emotion in happy and sad speech tokens in previous research (e.g. Singh et al., 2001, Singh et al., 2004).

Measures of maternal emotion expression and production

Upon arrival, mothers were given two informed consent forms (one for them to keep and one for our records; see Appendix C) as well as a family demographic sheet (see Appendix D). They were also provided with two additional questionnaires- Self Expressiveness in Family Questionnaire (SEFQ) (Appendix E) and Positive Affect and Negative Affective Scale Schedule (PANAS) questionnaire (Appendix F). The SEFQ measures the degree of emotional expressiveness of an individual within the family context. There are 40 hypothetical affective scenarios included in the questionnaire which represent a range of emotions found typically in a family setting. The responder is asked to indicate how frequently they express these emotions in each context. Twenty-three of

the scenarios represent the expression of positive emotion, whereas the other 17 of the items represent the expression of negative emotion. Thus, each individual generates two scores: SEFQ$_{pos}$ and SEFQ$_{neg}$. The external validity of the SEFQ is considered quite high in that family expressiveness and individual expressiveness are significantly and positively correlated from childhood to adulthood (Halberstadt, 1991; Halberstadt, Fox, & Jones, 1993). Also, the SEFQ has a high test-retest reliability (r =.72) and internal consistency (Cronbach's alpha = .9). In the present study also, the internal consistency of the positive SEFQ sub-scale (Cronbach's alpha = .88) and negative SEFQ sub-scale (Cronbach's alpha = .87) was high.

Unlike the SEFQ, the PANAS measures general emotional state (independently of expressiveness).   That is, the responder is asked to indicate the extent to which they generally feel certain emotional states, such as interest, guilt, and irritability. There are 20 descriptors, 10 positive and 10 negative. Thus, each individual derives a positive affect and a negative affect score. The PANAS has been used extensively with different populations including adolescents and elderly(Karatzias, Chouliara, Soliday, Power & Swanson, 2006; McConville, Simpson, Rae, Polito, Andriollo-Sanchez, Meunier, Stewart-Knox, O'Connor, Roussel, Cuzzolaro, Coudray, 2005). This scale has high test-re-test reliability (PA, r = .68; NA, r = .71) and internal consistency (PA, r = .88, NA, r = .87). In the present study, the internal consistency of the positive PANAS sub-scale (Cronbach's alpha = .84) and negative PANAS sub-scale (Cronbach's alpha = .87) was high.

Procedure

Once the written forms were filled out by the mother, and the experimenter had assessed that the infant was in a quiet and alert state, the infant and the mother were escorted to a dimly lit testing room. There was one trained observer who stayed in the testing room with the parent and infant (standing behind and out of the view of the infant) and another observer who was located in an adjacent room controlling the session, and observing the infant's looking behavior. The parent holding the infant was asked to remain silent to prevent interfering with the test. All sessions were recorded for inter-rater reliability assessment later.

Habituation Phase. The procedure employed here was an infant-controlled visual habituation paradigm. A blinking red dot was used as a centering event to draw the infants' gaze and attention to the computer screen. The observer depressed the space bar of the computer whenever the infant looked at the monitor, and released the space bar when the infant looked away. A 1 sec 'look-away' criterion was programmed into the procedure such that if the infant looked away but looked back within this time, the trial continued uninterrupted. Once the space bar was depressed for 3 continuous seconds, the centering event went off, and an AV presentation of a woman articulating two carrier sentences (each contained the same nonsense word) was presented. For example, one infant saw and heard her say "This is the sweetest NEEM that I have ever seen! We all laughed at the big, red NEEM!" This AV event played continuously until the infant looked away from the screen for at least 1 sec, at which time the AV presentation went off, and the centering event returned. This sequence constituted one trial, and was repeated for as many trials as needed to meet the habituation criterion. 'Habituation' was

defined as a 50% reduction in each infant's looking time for two successive trials relative to the average looking duration on the first two trials of the session (called baseline trials).

Testing phase. After the criterion for habituation was met, the next trial contained a novel AV presentation of the same female speaker, saying the same carrier sentences, in the same emotional tone, but with a novel nonsense word. In the example given above, the infant would then see and hear the woman saying "This is the sweetest BOOG that I have ever seen! We all laughed at the big, red BOOG!" The testing phase always began with a change to the novel word (called a "novel" trial), followed by a trial during which the infant was presented with the same AV sequence that they experienced during habituation (called a "familiar" trial). These novel and familiar trials alternated for 8 total test trials (4 novel; 4 familiar). Because infant looking can be highly variable from one trial to the next (Ashmead & Davis, 1996), multiple novel and familiar trials were presented to provide a more stable assessment of infant discrimination. That is, if infants discriminated the change to the novel word, then average looking times would be higher on novel than familiar trials. All infants were required to complete at least 4 consecutive trials to be considered in the final analysis.

<div align="center">Results</div>

Interobserver reliability

Inter-observer reliability was calculated offline by two trained observers for 25% of the infants. For those sessions randomly selected for reliability coding, each trial within a session was coded twice (the original online-observer and one offline-observer)

and Pearson's bivariate correlations was calculated. The average bivariate correlation was 0.99.

Analyzing for attention differences during habituation

One analysis of interest is whether infants in the Happy condition attended more to the AV movies during habituation than those infants in the Sad condition to see whether the emotion of the speaker influenced looking time during habituation. First, the average of the two initial trials (baseline average) and the average of the two trials before the switch to the novel word (prechange average) were compared to evaluate whether the initial degree of attention to the events differed as a function of emotion. A 2 x 2 mixed ANOVA was conducted with trial (baseline, prechange) as a within-subject factor and condition (happy, sad) as a between-subject factor. The results of this test showed a statistically significant main effect of trial [F (1,33) = 82.43, p < .0001, η_p^2 = .71], and no other significant effects. Thus, the decrement from baseline to prechange averages was similar across emotion conditions: Happy ($M_{baseline}$ = 35.94 s, SD=21.19; $M_{prechange}$=9.36 s, SD=3.93) and Sad ($M_{baseline}$ =31.56 s, SD=15.44; $M_{prechange}$ =8.84 s, SD=3.93). Next, the number of trials required to meet the habituation criterion were compared to see if infants took longer to process the sentences in one emotion condition compared to the other. However, there were no significant differences in the mean number of trials to habituation as a function of emotion condition ($M_{number\ of\ trials-happy}$ = 7.26, SD = 3.66; $M_{number\ of\ trials-sad}$ = 6.87, SD = 3.75; t(33) = 0.31, p > .05, d = .1).

Word recognition as a function of emotion condition

In order to assess whether word recognition differed across emotion contexts, a 2 x 2 mixed ANOVA was conducted with trial (average prechange, average novel) as a

within subject factor and condition (happy, sad) as a between subject factor. There was a statistically significant main effect of trial [$\underline{F}(1,33) = 10.45$, $\underline{p} < .003$, $\eta_P^2 = .24$], with the average looking time on novel trials being significantly longer than that on the average prechange trials. There was no significant trial x condition interaction [$\underline{F}(1,33) = 2.67$, $\underline{p} > .05$, $\eta_P^2 = .07$) . Because it was predicted that infants would show better recognition of the word change in the Happy condition, an additional analysis of simple main effects of the trial x condition interaction was carried out. This contrast showed a significant difference in average looking times on the prechange trials when compared to the novel trials in the Happy condition ($\underline{M}_{prechange} = 9.37$, $\underline{SD} = 3.93$; $\underline{M}_{novel} = 15.12$, $\underline{SD} = 7.03$, $\underline{t}(18) = -3.09$, $\underline{p} < .007$, $\underline{d} = 1.01$) (See Figure 1). In contrast, there was no significant difference in average looking times between prechange trials and novel trials in the Sad condition ($\underline{M}_{prechange} = 8.84$, $\underline{SD} = 3.92$; $\underline{M}_{novel} = 10.73$, $\underline{SD} = 6.12$, $\underline{t}(16) = -1.43$, $\underline{p} > .05$, $\underline{d} = .37$) (see Figure 2).

In order to ensure that recovered attention only occurred on the novel test trials, a second 2 x 2 mixed ANOVA was conducted with trial (average prechange, average familiar) as a within subject factor and condition (happy, sad) as a between subject factor. In this case, no significant differences between average looking times on prechange trials and familiar trials should be seen, regardless of emotion condition. The results of this analysis showed no significant main effect of trial [$\underline{F}(1,33) = 2.59$, $\underline{p} > .05$, $\eta_P^2 = .07$] and no trial x condition interaction [$\underline{F}(1,33) = .83$, $\underline{p} > .05$, $\eta_P^2 = .02$]. To be consistent with the analysis reported above, simple main effects were also carried out on the trial x condition interaction. This contrast showed no significant difference between average prechange trials and average familiar trials in either the Happy condition ($\underline{M}_{prechange} =$

9.37, $\underline{SD}$ = 3.93; $\underline{M}$ $_{familiar}$= 12.97, $\underline{SD}$ = 10.61, $\underline{t}$(18) = -1.54, $\underline{p}$ > .05, $\underline{d}$ = .36) or the Sad

condition ($\underline{M}$ $_{prechange}$= 8.84, $\underline{SD}$ = 3.93; $\underline{M}$ $_{novel}$= 9.85, $\underline{SD}$ = 6.09, $\underline{t}$(15) = -.72, $\underline{p}$ > .05, $\underline{d}$ =

.19) (See Figures 3 and 4).

Additionally, a third 2 x 2 mixed ANOVA was conducted with trial (average

novel, average familiar) as a within-subject factor and condition (happy, sad) as a

between-subject factor. There was no significant main effect of trial [$\underline{F}$(1,33) = 1.04, $\underline{p}$ >

.05, η_P^2 = .03] or trial by condition interaction [$\underline{F}$(1,33) = .18, $\underline{p}$ > .05, η_P^2 = .005].(See

Figures 5 and 6).

Since a significant difference was predicted between average novel and average

familiar trials in the Happy condition, a separate analysis of subjects who completed both

blocks in the testing phase was also done. There were 14 subjects in the Happy condition

and 14 subjects in the Sad condition. There was a statistically significant main effect of

trials [$\underline{F}$(1,26) = 6.98, $\underline{p}$ < .003, η_P^2 = .21]. There no significant trial x condition

interaction. However, analysis of simple main effect was carried out. Paired t-test in the

Happy Condition showed a significant difference between average prechange ($\underline{M}$

$_{prechange}$=9.76, $\underline{SD}$ = 4.2) and average novel trials ($\underline{M}$ $_{average\ novel}$= 13.42, $\underline{SD}$ = 5.55) [$\underline{t}$(13)

= -2.14, $\underline{p}$ < 0.05, $\underline{d}$ = .74] as well as average familiar ($\underline{M}$ $_{average\ familiar}$= 8.92, $\underline{SD}$ = 3.68)

and average novel trials ($\underline{M}$ $_{average\ novel}$= 13.42, $\underline{SD}$ = 5.55) [$\underline{t}$(13) = -3.45, $\underline{p}$ < 0.005, $\underline{d}$ =

.95]. Paired t-test in the Sad Condition did not show any significant effects.

The above analyses were conducted with average looking times on prechange,

novel, and familiar trials. Another analysis of interest was the ratio of average looking on

novel and familiar trials with respect to the prechange trials, in order to more directly

compare the degree of increased attention to the change in the target word. To do so,

percent novelty scores were calculated by dividing the average looking time on novel trials by the sum of this same value plus average looking time on prechange trials (and multiplying by 100). If the amount of attention on both trial types is equal, this value will be 50%. Scores greater than 50% indicate the degree of increased attention to the novel word. Percent novelty scores were significantly greater than 50% in the Happy condition [$\underline{M}$ percent novelty score = 60.44, $\underline{SD}$ = 14.49, $\underline{t}(18)$ = 3.14, $\underline{p}$ < .006, $\underline{d}$ = 1.48] but not in the Sad condition [$\underline{M}$ percent novelty score = 52.93, $\underline{SD}$ = 11.03, $\underline{t}(15)$ = 1.06, $\underline{p}$ > .05, $\underline{d}$ = .55], and this was true for 15 out of 19 infants in the Happy condition (binomial probability, $\underline{p}$ < .01; two-tailed). In contrast, only 9 out of 16 infants in the Sad condition had percent novelty scores greater than 50% ($\underline{p}$ > 0.05). When percent familiarity scores were calculated in likewise fashion, tests confirmed that they were not significantly greater than 50% in either the Happy [$\underline{M}$ percent familiarity score = 43.8, $\underline{SD}$ = 1.93, $\underline{t}(18)$ = -2.08, $\underline{p}$ > .05, d = .98] or Sad [$\underline{M}$ percent familiarity score = 48.73, $\underline{SD}$ = 13.34, $\underline{t}(15)$ = -0.38, $\underline{p}$ > .05, $\underline{d}$ = .19] conditions.

Infant facial affect as a function of emotion condition

In order to examine whether infants' facial emotional expressions were influenced by the emotion being conveyed by the female speaker in the two conditions, observations of infant expressiveness were conducted offline from taped sessions. Positive facial affect during individual trials was rated using a scale from 1 to 4 with 1 indicating no positive affect (e.g. neutral expression) and 4 indicating highest level of positive emotion (e.g. laughter) (see Appendix G and H). Similarly, negative facial affect during individual trials was also rated using a scale from 1 to 4 with 1 indicating no negative affect (e.g. neutral expression) and 4 indicating highest level of negative emotion (e.g. crying). Both

positive and negative affect were rated for the same trials in order to better capture the full range of facial affect that infants may have displayed while attending to the Happy and Sad movies. Inter-observer reliabilities were calculated offline by two trained observers for 25% of the infants tested. For those sessions randomly selected for reliability coding, Pearson's bivariate correlation was calculated. The average bivariate correlation was 0.97.

Next, paired sample tests were computed in order to compare average positive and average negative facial emotion expressed in the two conditions. In the Happy Condition, there were significantly higher positive emotion scores ($\underline{M} = 1.36$, $\underline{SD} = .38$) compared to negative emotion scores ($\underline{M} = 1.05$, $\underline{SD} = .09$), $\underline{t}(18) = 3.64$, $\underline{p} < .002$, $\underline{d} = 1.18$). In contrast, there was no significant difference between positive emotion scores ($\underline{M} = 1.16$, $\underline{SD} = .27$) and negative emotion scores ($\underline{M} = 1.16$, $\underline{SD} = .19$), $\underline{t}(18) = .05$, $\underline{p} > .05$, $\underline{d} = .02$) in the Sad condition. Percent novelty scores were neither significantly correlated with infants' positive emotion scores ($\underline{r} = +.39$, $\underline{p} > 0.05$, $\underline{d} = .84$) nor their negative emotion scores ($\underline{r} = .01$, $\underline{p} > .05$, $\underline{d} = .02$) in Happy condition. Although correlated in the opposite direction, the percent novelty scores were neither significantly correlated with infants' positive emotion scores ($\underline{r} = -.39$, $\underline{p} > .05$, $\underline{d} = .84$) nor their negative emotion scores ($\underline{r} = 0.08$, $\underline{p} > 0.05$, $\underline{d} = .16$) in the Sad condition either. Correlations between positive and negative facial affect in the Happy and Sad condition with trials 1, 2, 3 and 4 and percent novelty and percent familiarity preference were calculated and it revealed no significant effects (see Table 2).

Maternal emotional expressiveness and experience

SEFQ scores and infant attention

As an exploratory measure, maternal emotional expressiveness in the family context was analyzed. The SEFQ ratings by mothers were further sub-divided into positive and negative categories reflecting expressiveness of positive and negative emotions respectively.

Correlations between looking times on trial 1, 2, 3, and 4, percent novelty and percent familiarity preference and positive and negative SEFQ scores in both Happy and Sad conditions were computed (See Table 2). Because one of the infant's looking time on the first trial was more than 3 standard deviations higher than the group average (in the Sad condition), this infant was dropped from the analysis. In the happy condition ($\underline{n}$ = 19), looking time on Trial 1 was not correlated with either positive SEFQ ($\underline{r}$ = +.38, $\underline{p}$ > .05, $\underline{d}$ = .83) or negative SEFQ ($\underline{r}$ = +.31, $\underline{p}$ > .05, $\underline{d}$ = .65). However, in the Sad condition ($\underline{n}$ = 15), positive SEFQ was positively correlated with looking time on Trial 1 ($\underline{r}$ = +.665, $\underline{p}$ < .009, $\underline{d}$ = 1.77) (See Figure 7). Negative SEFQ was not correlated with looking times on Trial 1 ($\underline{r}$ =+ .194, $\underline{p}$ > .05, $\underline{d}$ = .39). Other correlations were not significant.

Since SEFQ measure can also be scored using three factors (positive SEFQ, NS or Negative Submissive scale and ND or Negative Dominance scale), another set of calculations were computed specifically to assess the relationship between positive SEFQ and NS. The NS scale is related to expression of sadness (Halberstadt et al., 1995). In the Happy condition, there was no significant relationship between positive SEFQ and NS ($\underline{r}$

= .31, $\underline{p}$ >.05)) and in the Sad condition also, there was no significant relationship between positive SEFQ and NS ($\underline{r}$ = -.12, $\underline{p}$ > 0.05).

<u>PANAS ratings and infant attention</u>

As a second exploratory measure, mothers' general affect was analyzed using the Positive Affect and Negative Affect Schedule (PANAS). Like the SEFQ ratings, the PANAS ratings are also further divided into positive and negative sub-scale.

As with the SEFQ measures discussed above, mothers' positive and negative PANAS scores were correlated with infants' looking times on different trials as well as with their percent novelty and percent familiarity preference (see Table 2). Intercorrelations between the different maternal measures of emotional experience and expressiveness were also calculated (see Table 3). In the happy condition, looking time on Trial 1 was significantly negatively correlated with positive PANAS scores ($\underline{r}$ = -.51, $\underline{p}$ < .03, $\underline{d}$ = 1.18) (See Figure 8). However, looking time on Trial 1 was not significantly correlated with negative PANAS scores ($\underline{r}$ = +.24, $\underline{p}$ > .05, $\underline{d}$ = .49). In the Sad condition, looking time on Trial 1 was neither significantly correlated with positive PANAS scores ($\underline{r}$ = +.17, $\underline{p}$ > .05, $\underline{d}$ = .35) nor negative PANAS scores ($\underline{r}$ = -.04, $\underline{p}$ > .05, $\underline{d}$ = .08). Other correlations were not significant.

<div align="center">Discussion</div>

The main goal of this study was to investigate the influence of a speaker's emotional expression (both face and voice) on word recognition in 11-to-13-month-old infants. In the present study, infants were first habituated to sentences containing a nonsense word ('neem' or 'boog') in either a happy or a sad emotional context, and then tested with the same carrier sentences but with a *novel* nonsense word and the same

carrier sentences with the familiar nonsense word. The emotional context was held

constant across the entire sequence. Hence, the infants were habituated and tested within

the same emotional condition. Because it was predicted that the happy context would

elicit greater attention and hence facilitate improved word processing, the major

prediction was that infants would show word recognition (i.e., recovery of attention) in

the happy condition, but not in the sad condition. Overall the major hypothesis of this

study was supported in that infants showed increased attention during test trials that

contained the novel word, but only in the Happy condition. This finding was evident in

two measures, both in terms of average looking time during different types of trials (e.g.,

novel-test vs. familiar-test) when compared to prechange looking times, and in that the

ratio of looking time on novel to prechange trials was greater than 50% for 15 out of the

19 infants in the Happy condition, but only for 9 out of the 16 infants in the Sad

condition.

However, the infants in the Happy condition did not show significantly longer

average looking times on the novel vs. familiar trials, even though only the average

looking times on novel trials were significantly longer than those on prechange trials.

Similar findings have been observed in experiments using similar habituation paradigms

in which dishabituation to the novel event reinvigorated interest in the subsequent

familiar event (referred to as 'Thompson-Spencer dishabituation'; Kaplan, Werner, &

Rudy, 1990). Such renewed attention to the familiar event does not necessarily reflect a

disruption of the habituation process but indicates heightened sensitization and has

previously been observed in infants, especially as event complexity increases (Kaplan &

Werner, 1986). In the present study, the sentences presented to the infants can be

considered a more complex speech event compared to isolated words or phonemes. Therefore, it is possible that infants continued to look longer at the AV movies containing the carrier sentences with the familiar word after initially seeing the movies with the novel word because of sensitization. One way to test this possibility would be to counterbalance the order of test trials (i.e., after habituation, present the familiar movie first for half of the infants). Infants should increase attention to the novel speech event irrespective of this order, but should show less attention to the familiar speech event when it occurs first vs. when it occurs after the novel event. This strategy was not implemented in the current study in an attempt to minimize infant attrition by presenting a novel event on the first trial after habituation (when attention is quite low), but then presenting multiple familiar trials to assay "rehabituation."

When a separate analysis was carried out using data only from the subjects who completed both blocks in the testing phase, it was seen that in the Happy condition there was a significant difference not just between pre-change and average novel trials but also between average novel trials and average familiar trials. This difference was not evident in the Sad condition. This finding illustrates the eventual decrease in sensitization of infants. Hence, if only subjects who had completed both blocks were included in the final analyses, it would have demonstrated clear word recognition in that not only are the average novel trials longer than the pre-change trials but also greater than the average familiar trials.

Given that infants showed word recognition in the Happy condition and not in the Sad condition, an important question here would be whether infants paid more attention to the Happy AV movies during the habituation phase. However, this did not seem to be

the case, as there were no significant differences found in the looking time on the first two trials, or the number of trials needed to meet the habituation criterion in either emotional context. Thus, according to these comparisons, attention seemed to be fairly equal across both Happy and Sad habituation sequences.

These similarities in infants' attention across the two emotion conditions are corroborated by the relationships between maternal measures and infant looking patterns during the initial part of habituation. Two measures of maternal emotion (positive SEFQ and positive PANAS) were found to be significantly correlated with infants' looking times on the first trial of the sessions. In the Happy condition, mothers' positive mood was negatively correlated with infants' looking times, meaning that infants of mothers with lower positive mood tended to look longer at a happy female speaker than infants of mothers with more positive mood. In the Sad condition, mothers' positive emotional expressiveness was positively correlated with looking time on the first trial. That is, infants of mothers who reported greater expression of positive emotion tended to look longer at a sad female speaker. When another version of SEFQ involving NS (or Negative Submissive scale which is specifically related to expression of sadness) was computed, it showed no relationship between the positive expressiveness and the negative submissive scale. If this relationship had been positively correlated, it would have indicated that mothers expressing more positive emotions are also expressing more sadness. It is possible that a significant effect would have been observed with a larger sample size. But in view of the present findings, together, these correlations indicate that infants' attention appeared to be enhanced by a dynamic female speaker portraying an emotional state unlike the one generally experienced or expressed by their own mothers.

Thus, high levels of infant attention were elicited in both emotion conditions, but based on the infants' experiences with their own mothers' emotional tendencies. Because of the small sample size, it would not be suitable to draw broader conclusions from this study alone but the differential effects of mothers' emotional experience and expressivity on infants' looking times provides an interesting direction for further research.

The findings of the current study are similar to Singh et al.'s study (2004) in that infants showed word recognition in the happy context in both studies even though different research paradigms and methodology were employed. Unlike Singh et al., however, emotional condition in the present study was kept constant across habituation and testing phases. Yet another important aspect of the current study was the fact that the infants were habituated to the target words in an auditory/visual context. It has been demonstrated that infants around the age of 5 to 7 months match happy faces with happy voices and sad faces with sad voices (Walker-Andrews, 1988; Walker-Andrews & Lennon, 1991). Recent work by Flom and Bahrich (2007) with 3-, 4-, 5-, and 7-month-olds' perception of affect across auditory, visual and audio-visual modality has shown that with bimodal (audio-visual) stimulation, discrimination emerges around 4 months of age and remains stable. In unimodal stimulation (auditory or visual alone), sensitivity to auditory stimulation emerges earlier at 5 months of age than visual stimulation at 7 months of age. Given that infants showed word recognition only in the happy emotional context, it is reasonable to conclude that the emotional state of speakers (as conveyed by facial and vocal information) during caretaker-infant interactions influences the processing of speech.

Why does positive face+voice emotion support word learning?

It has been shown that infants show a preference for positive vocal affect in the first half year after birth (Kitamura & Burnham, 1998; Panneton et al., 2006; Singh et al., 2001). In the present study, older infants were tested for their word recognition under different emotional contexts but it still seems that positive affect provided a perceptual pull for the infants leading to improved word recognition. In a related study, Ostroff, Panneton, and Maslow (2007) found that 10-month-olds preferred IDS in their native language over IDS in non-native languages. In contrast, same-aged infants showed no native language preference when the speech was adult-directed directed. Although this study did not manipulate speaker emotion per se, infants' preferences for their native language only when infant-directed suggests that the heightened positive emotion in IDS facilitated attention to linguistic structure.

At least one study has found that mothers' IDS to 9-month-olds, when compared to both younger and older samples, is lower in positive affect and average pitch but greater in pitch range and more directive in its function (Kitamura & Burnham, 2001). These authors found that mothers' IDS to 12-month-olds showed a resurgence in emotion attributed to offering encouragement as language development accelerates. So it is possible that as infants age, they first learn to integrate positive emotion information that is available in both faces (e.g., smiling) and voices (e.g., exaggerated prosody) with linguistic level information (e.g., words), but have not yet accomplished this same level of integration between negative emotion information and language. In the current study, this means that although infants' attention was high, the infants were processing different

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aspects of the movies depending on the emotion conditions: infants in the Happy condition were processing both emotion-specific and language-specific information.

In addition to this integrative advantage, infants are gleaning a lot of information from the face and voice in speech processing (Lewkowicz, 1992, 2000, 2003). When a particular speech register like IDS is used, then it might further heighten attention to both the face and voice (Cooper & Aslin, 1994; Werker & McLeod, 1989). The acoustic characteristics of speech events in this study with higher pitch, pitch range and intensity in the Happy condition than Sad condition might be responsible for infants showing word recognition in the former condition but not the latter even though both were infant-directed events. Besides the acoustic attributes, the visuo-facial aspects of IDS with exaggerated mouth and lip movements also draws attention to the nonsense words ('neem' and 'boog') which are very different in their enunciation styles. If similar sounding words (e.g. 'neem' and 'meem') are used for testing infants' word recognition across different emotional conditions, then it might be more difficult both visually and acoustically to detect a change.

Why does negative face+voice emotion fail to support word learning?

In this study, infants did not show word recognition when they were tested with Sad speech events. This finding could be attributed to different possible reasons. The sad context failed to engage infant attention specifically due to the auditory aspect of the AV movie because of its low pitch, pitch range and intensity. The visuo-facial aspect did not help either. Instead of the animated faces they are exposed to in their general environment, the sad face coupled with sad speech probably could not engage and/or maintain their attention. However, the lack of difference in looking times by infants in the

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both the Happy and Sad conditions during baseline as well as the number of habituation trials do not support the above stated premise. It is possible that infants did recognize the novel event but were not motivated to show increased looking time after habituation. Another possibility would be that infants are not integrating the affective and linguistic aspects of the sad speech event as they are focusing on the emotional facet of the auditory/visual speech event and are not processing the word. Infants possibly master this task of integrating emotional and linguistic features of speech independent of emotions at an older age as they gain more experience with the structure of language but this might not be evident at the age tested in this study. It would be useful to compare older infants' and toddlers' word recognition under different emotional conditions including positive and negative emotions.

In order to understand the contribution of visuo-facial and auditory aspects on word recognition, it would be insightful to match dynamic happy faces with sad voices and vice-versa. If infants showed increased looking time on the novel event when the face is happy and the voice is sad, it would imply a more prominent role of faces in capturing attention to processing of speech. On the other hand, if infants showed increased looking time on the novel event when the face is sad and the voice is happy, it would imply the eminence of voices in speech processing and word recognition. Ultimately, if infants' performance on word recognition with emotions matched in face and voice is compared to the above-mentioned mismatch across faces and voices, the former should be superior to the latter. Language acquisition generally takes places in a bimodal and dynamic context.

It would also be interesting to know if infants show word recognition across emotional contexts. If infants are habituated or familiarized to speech events in happy emotional condition and then tested under sad emotional context, would they show word recognition? On the other hand, if exposure to the speech event occurs in a sad emotional context and tested in a happy emotional context, would learning be impaired? If the answer is yes, it would reiterate the above-mentioned premise that the input phase is crucial for word recognition and learning and probably more important than the testing phase. If not, then it might indicate that a supportive testing context could override a non-supportive input phase. It would also show that it is not just the input phase which is crucial but also the testing phase.

Role of emotion in language development

It has also been hypothesized that neutral affect might be essential for processing of language (Bloom, 1993, 1997). It has been demonstrated that infants showing more neutral affect achieve language milestones earlier than infants expressing either more positive or negative affect (Bloom & Capatides, 1987). Interestingly, in the present study, comparisons of infants' facial affect across Happy and Sad conditions provides a slightly different perspective. Infants in the Happy condition showed more positive facial affect than negative affect but infants in the sad condition did not show any difference in expression of positive and negative affect. The differential facial affect observed in this study has been reported in previous studies in which infants at different ages produced the same emotion facially as the speakers' facial and vocal emotion whether it was positive or negative (e.g. Izard et al., 1995). Infants have shown more positive affect to statements involving approval and more negative affect to statements with prohibitions in

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IDS in both native and non-native languages (Fernald, 1993). But these earlier findings have not been specifically related to infant performance on word recognition whereas in the current study, infants in the Happy Condition showed word recognition and infants in the Sad Condition did not. Comparison of infants' performance and facial affect on word recognition tasks involving neutral emotion as well as positive and negative emotions could provide vital cues regarding the relationship between emotional affect displayed by infants and their performance in a learning task involving speech perception..

Besides the influence of facial affect of infants on their own language acquisition how important is the role of input the infants are receiving? Do they learn better if the speakers show little or no emotion both vocally and facially? The findings from the present study would lead us to believe that it is probably not true. However, it would be interesting to compare the rate at which word recognition takes place in happy emotional context compared to neutral emotional context in a bimodal speech context. It is possible that faster word recognition occurs with neutral emotional context at least for older infants or there might be no difference. As infants grow into toddlers and then children, they might show better integration of affective and linguistic aspects of speech (auditory/visual) irrespective of the emotional context in which they are tested.

Summary and future considerations

To summarize the current study, 11-to-13-month-olds showed word recognition in a face+voice context when they were tested in the Happy condition but not in the Sad condition. Infants might have integrated both emotional and linguistic information from the visuo-facial and auditory domains of the happy event. No word recognition was seen

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by infants in the Sad condition. Infants might have focused more on the affective features of the event rather than the linguistic aspect of this audio-visual speech event.

Use of an eye-tracking instrument to trace infants' eye movements during word recognition task involving faces and voices could help identify their focus of attention while processing positive or negative audio-visual speech events. Infants might be focusing more on the face of a happy speaker (especially their lips and mouth) compared to a sad speaker and this might aid speech processing. Further, the role of dynamic faces and voices in word recognition and speech processing can be teased apart by testing infants at different ages with static and/or dynamic faces coupled with voices in both positive and negative emotional context. Also, older children's language learning can be assessed under positive, negative and neutral emotional conditions under different audio-visual contexts.

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Table 1

Acoustic analyses of words: means and SD

Words	Mean F_0 (Hz)	Min F_0 (Hz)	Max F_0 (Hz)	F_0 range	Intensity (db)
Happy	296.37 (38.6)	257.13 (37.19)	342.12 (43.89)	85 (41.2)	72.66 (0.35)
Sad	207 (74.58)	201.25 (72.75)	216.5 (74.36)	15.25 (7.63)	66.66 (2.19)

Table 2

Correlations between trials, percent novelty and percent familiarity preference and SEFQ and PANAS measures in Happy and Sad conditions

HAPPY							
	Trial 1	Trial 2	Trial 3	Trial 4	Percent Novelty	Percent Familiarity	Mean (SD)
Positive SEFQ(2 factor)	-0.38	-0.17	-0.17	-0.38	0.11	-0.001	6.96(0.89)
Negative SEFQ(2 factor)	0.31	-0.08	-0.22	-0.22	0.23	-0.41	4.05(1.11)
Positive SEFQ (3 factor)	-0.46	-0.15	-0.19	-0.42	0.18	-0.05	7.09(0.88)
NS (3 factor)	0.16	-0.02	-0.24	-0.25	0.13	-0.26	5.77(1.09)
ND (3 factor)	0.31	-0.18	-0.14	-0.17	0.17	-0.33	3.33(1.16)
Positive PANAS	-0.51[*]	-0.12	-0.27	-0.15	0.15	0.11	3.74(0.56)
Negative PANAS	0.24	-0.28	-0.25	0.002	0.31	0.08	1.83(0.62)
Infant Facial Positive Affect	-0.27	-0.36	-0.36	-0.16	0.39	0.05	1.36(0.38)
Infant Facial Negative Affect	0.19	-0.18	-0.005	-0.02	0.01	-0.03	1.05(0.09)

SAD							
	Trial 1	Trial 2	Trial 3	Trial 4	Percent Novelty	Percent Familiarity	Mean (SD)
Positive SEFQ(2 factor)	0.66[**]	0.42	0.44	0.26	-0.03	0.07	6.74(0.9)
Negative SEFQ(2 factor)	0.06	0.12	0.005	-0.21	0.1	-0.42	3.96(1.1)
Positive SEFQ (3factor)	0.6[**]	0.5	0.45	0.3	-0.16	0.12	6.95(1.14)
NS (3 factor)	0.32	-0.26	-0.13	-0.18	0.34	-0.46	5.16(1.09)
ND (3 factor)	-0.13	0.03	0.07	-0.28	0.08	-0.35	3.51(1.03)
Positive PANAS	0.17	0	0.34	0.08	0.04	0.3	3.69(0.53)
Negative PANAS	-0.04	-0.24	0.27	-0.34	-0.13	0.003	1.86(0.52)
Infant Facial Positive Affect	-0.05	0.31	0.2	-0.06	-0.4	0.06	1.16(0.27)
Infant Facial Negative Affect	-0.17	0.02	-0.06	-0.25	-0.1	-0.06	1.16(0.19)

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Table 3

Intercorrelations between different maternal measures

HAPPY							
	1	2	3	4	5	6	7
1. Positive SEFQ(2 factor)	1	-0.23	0.97^{**}	0.44	-0.39	0.77^{**}	-0.34
2. Negative SEFQ(2 factor)		1	-0.29	0.65^{**}	0.94^{**}	-0.29	0.58^{*}
3. Positive SEFQ (3 factor)			1	0.31	-0.45	0.78^{*}	-0.38
4. NS (3 factor)				1	0.41	0.25	0.24
5. ND (3 factor)					1	-0.43	0.61^{**}
6. Positive PANAS						1	-0.1
7. Negative PANAS							1

SAD							
	1	2	3	4	5	6	7
1. Positive SEFQ(2 factor)	1	-0.11	0.96^{**}	0.04	0.23	0.56^{*}	-0.11
2. Negative SEFQ(2 factor)		1	-0.1	0.74^{**}	0.95^{**}	-0.72^{**}	0.46
3. Positive SEFQ (3factor)			1	-0.12	-0.2	0.56^{*}	-0.17
4. NS (3 factor)				1	0.56^{*}	0.59^{*}	0.43
5. ND (3 factor)					1	-0.66^{*}	0.46
6. Positive PANAS						1	-0.33
7. Negative PANAS							1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Figure 1.

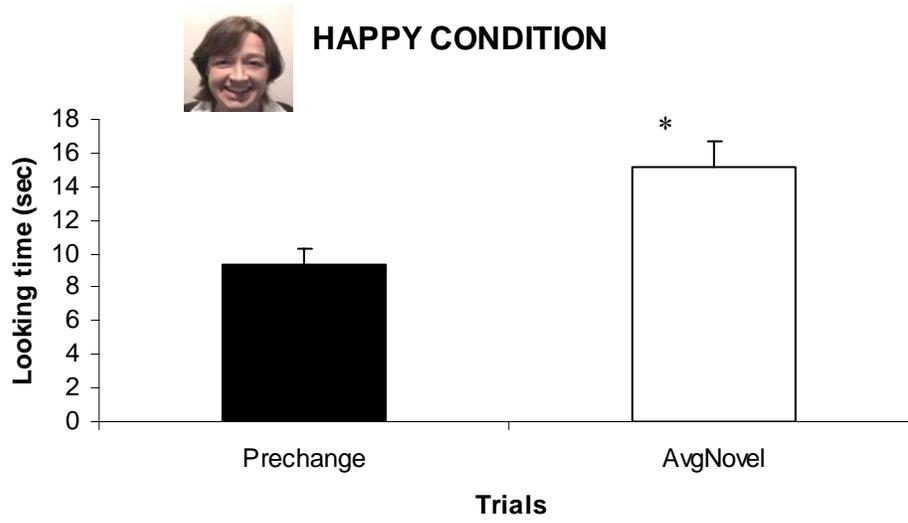Comparison of Prechange and Average Novel in Happy condition.

Figure 2.

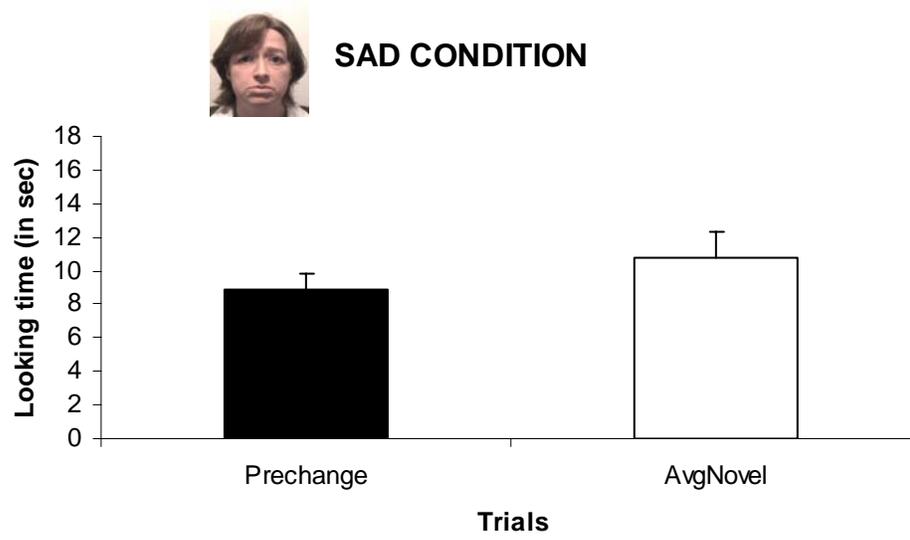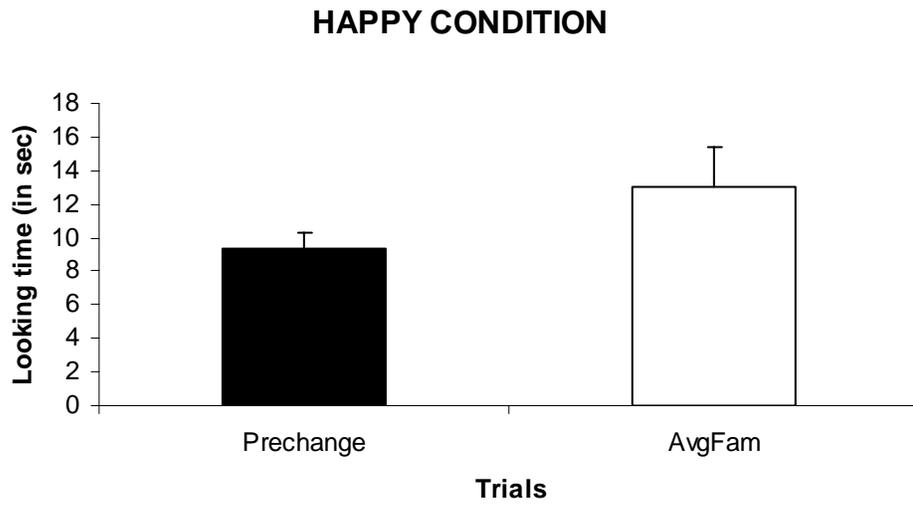Comparison of Prechange and Average Novel in Sad condition.

SAD CONDITION

Figure 3.

Comparison of Prechange and Average Familiar in Happy condition.

HAPPY CONDITION

Figure 4.

Comparison of Prechange and Average Familiar in Sad condition.
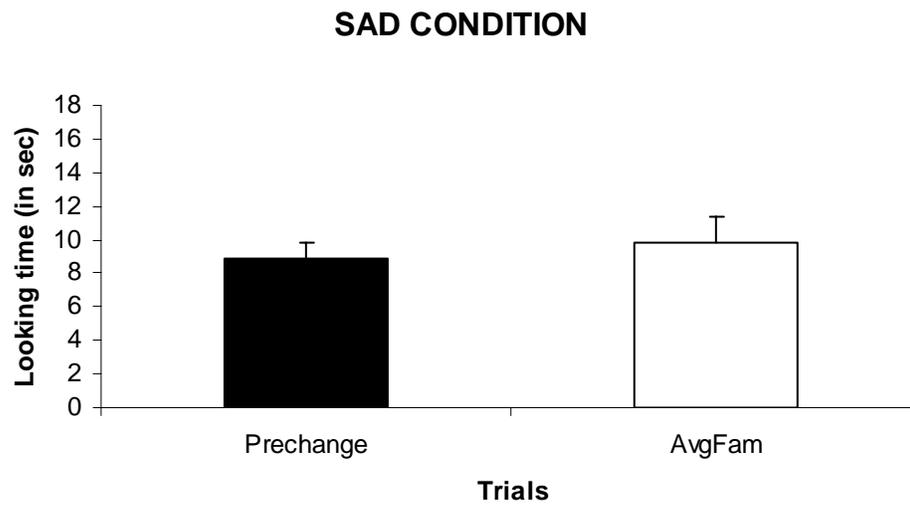
SAD CONDITION

Figure 5.

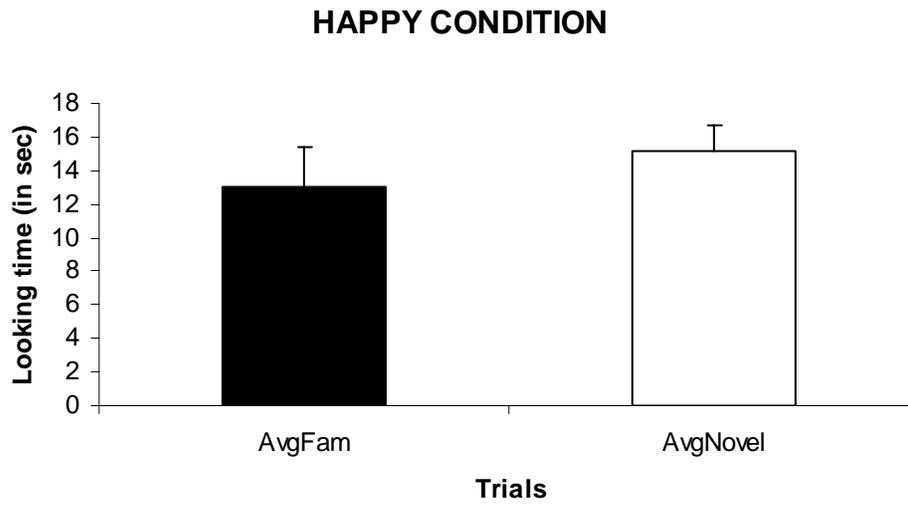Comparison of Average Familiar and Average Novel in Happy condition.

Figure 6.

Comparison of Average Familiar and Average Novel in Sad condition.

SAD CONDITION
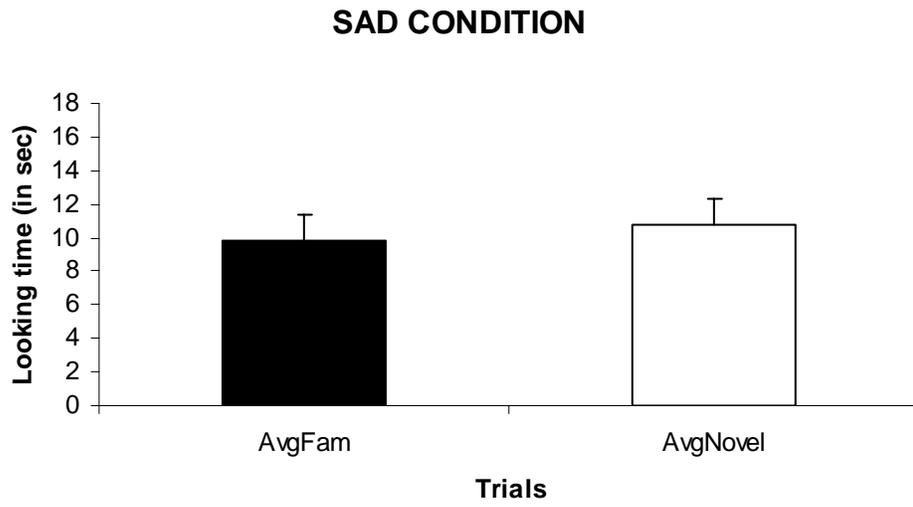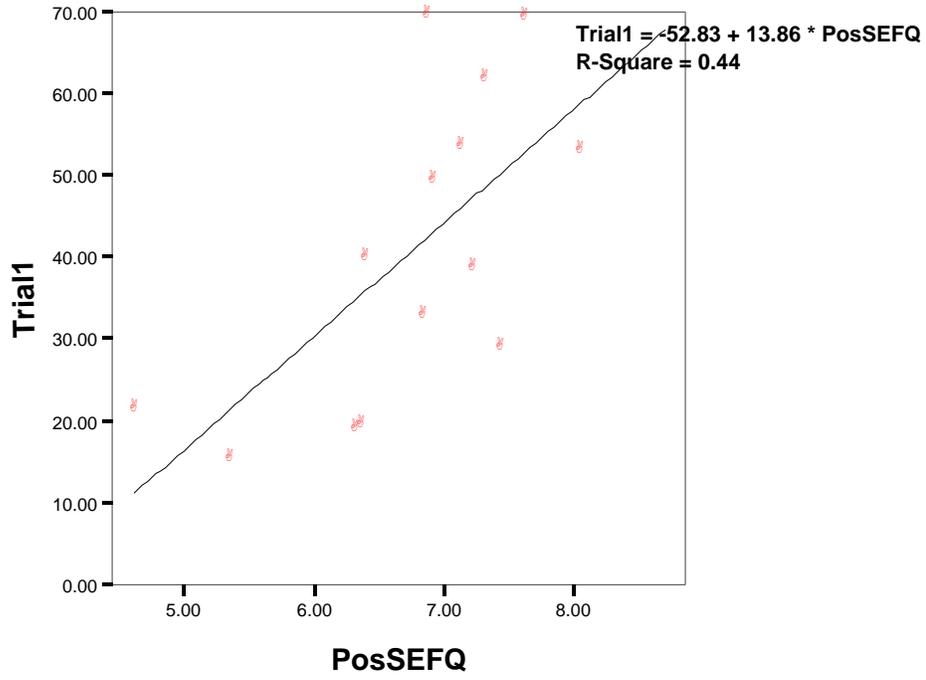
Figure 7

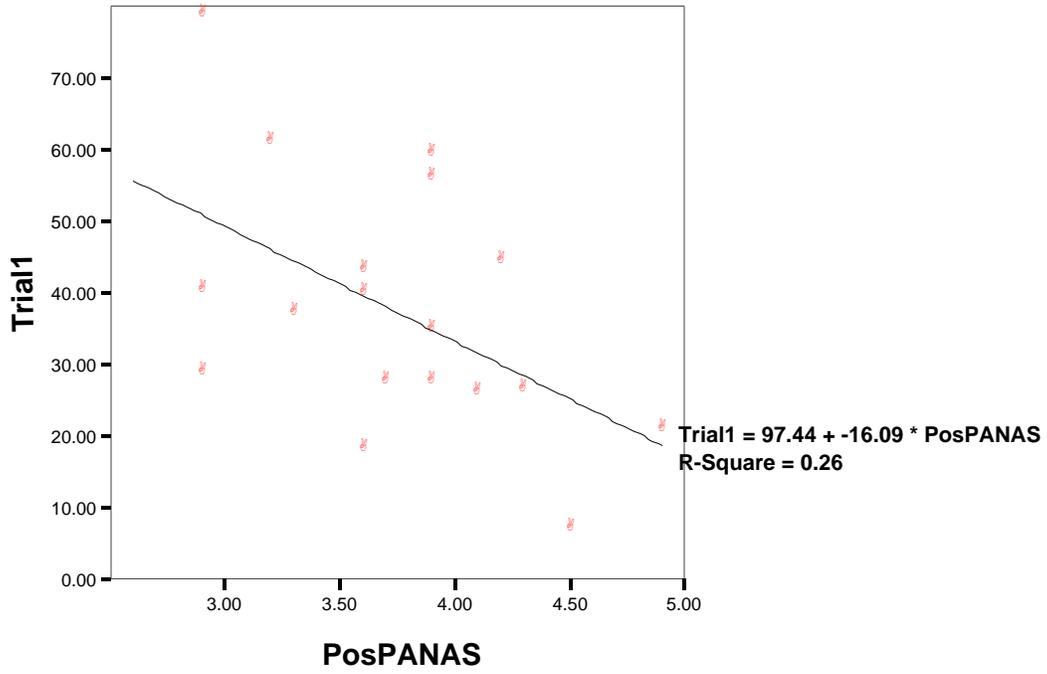**Looking Trial 1 with Positive SEFQ (Sad Condition)**

Trial1 = -52.83 + 13.86 * PosSEFQ
R-Square = 0.44

Figure 8

Looking Trial 1 with Positive PANAS (Happy Condition)

Trial1 = 97.44 + -16.09 * PosPANAS
R-Square = 0.26

Invitation letter to parents

INFANT PERCEPTION LABORATORY

DEPARTMENT OF PSYCHOLOGY
VIRGINIA TECH

Dear Parent(s):

Soon after infants are born, they can recognize many different objects, sounds and voices. Even though babies are not yet talking, we believe that they are actively listening and paying attention to people and events in the world around them. We are interested in studying how auditory and visual events affect the attention of infants, because this helps us to understand how infants begin to learn, speak, and develop relationships with those around them.

If you have the time and interest, *we would love to have you participate in one of our studies*! Your participation would involve one visit to the Infant Perception Lab, located on the 3rd floor of Williams Hall on the campus of Virginia Tech (a map is enclosed for your convenience). We will schedule a 30 minute appointment with you at your convenience (nights and weekends are available if you prefer). If there are older children in the family and you would like to bring them along, we offer free child care. We also have convenient parking next to our building on campus. If you are interested in scheduling an appointment, or like to find out more about our work, please feel free to call us at **231-3972** or visit our website at **http://www.psyc.vt.edu/infant_speech/**

Sincerely,

Robin Panneton, Ph.D.	Naureen Bhullar
Associate Professor	Graduate Researcher
panneton@vt.edu	nbhullar@vt.edu

Appendix B

Happy and sad sentences

<u>Happy sentences</u>:

This is the sweetest neem that I have ever seen.

We all laughed at the big, red neem.

This is the sweetest boog that I have ever seen.

We all laughed at the big, red boog.

<u>Sad sentences</u>:

The poor scared neem started to cry.

He lost his best neem today.

The poor scared boog started to cry.

He lost his best boog today.

Appendix C

Informed consent

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants of Investigative Projects

Title of Project: *The Effects of Facial and Vocal Emotion on Word Recognition in 11-to-13-Month-Old Infants*

Principle Investigators: **Naureen Bhullar, M.S. and Robin Panneton, Ph.D.**

I. Purpose of Research Project

We will test the ability of 11-to 13-month-old infants to learn words under two different emotion conditions: (1) when the speaker is happy, and (2) when the speaker is sad. We predict that infants will be more efficient in their encoding and recall of non-sense words when the speaker is happy.

II. Information from the infant

Your infant will be tested for approximately 15 minutes, provided that he/she is awake, alert, and quiet. You will hold your baby on your lap, and face a computer monitor. A colorful attention-getter will appear on the screen and when your infant looks at the screen, a movie of a woman will begin, speaking a sentence with a non-sense word in an infant-directed manner (e.g., "NEEM"). After your infant habituates to this speech token, he/she will then see the woman speaking the same sentences with a new non-sense word ("BOOG"). This movie will continue as long as your infant looks at the screen. Typically, if infants recognize the novel word, they will look longer on trials with new words. Half of the infants in this study will experience this word learning experience when the female speaker is happy, and the other half will experience this word learning experience when the female speaker is sad. We will compare the efficiency of infants' word learning under these two emotion conditions by recording the length of their visual fixations and also his/her heart rate (as a secondary measure of attention). This heart rate measure involves placing three, pediatric mildly-adhesive electrodes on the infant's chest.

We will create a digital recording of your infant during the session, so that we can watch the baby from an adjoining room in order to code his/her attention to the computer screen, and also so that we can have undergraduate assistants recode your baby's behavior and facial expressions at a later time (for reliability estimates). However, no identifying information about your baby will appear on these digital recordings.

III. Information from the mother

In addition to testing your infants' word recognition, we will also ask you to fill out several *confidential* forms (see statement below on confidentiality):

a) a brief demographic questionnaire
b) a short survey on your perception of your infant's emotional profile
c) a short survey on your general emotion expressiveness

IV. Risks

There are no apparent risks to your infant or to yourself for participation in this study. Sound levels for all auditory stimuli and for the parent's headphones will all be verified prior to the testing of each subject. The pediatric electrodes are designed for sensitive skin, easily removable, and will be thrown away following testing.

V. Benefits

While there are no direct benefits to the participants in this study, you and your infant's contributions will advance our understanding of the role of caretaker emotion in the process of language learning. Parents will receive a certificate of appreciation after the completion of each session.

VI. Extent of Anonymity and Confidentiality

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

VII. Compensation

There is no compensation to be earned from participation in this project.

VIII. Freedom to Withdraw

You have the right to terminate your involvement at any point in time and for any reason should you chose to do so.

IX. Subject's Responsibilities

I voluntarily agree to have my infant participate in this study.

X. Approval of research

This project has been approved by the Human Subjects Committee of the Department of Psychology and the Institutional Review Board of Virginia Tech.

XI. Subject's permission

I have read and understand the informed consent and conditions of this project. I have been given an opportunity to ask further questions about this procedure and I

understand I have the right to end this session for any reason if I so choose. 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 permission to Dr. Panneton, Naureen Bhullar, and the research assistants in the Infant Perception Laboratory to use my infant's visual and HR responses as a measure of word learning in this study.

Dr. Robin Panneton, Principle Investigator   231-5938
Naureen Bhullar, Graduate Assistant   231-3972
Dr. David Harrison, Chair, Human Subjects Committee   231-4422
David M. Moore, DVM, Assistant Vice Provost for
        Research Compliance   231-4991

Signature of Parent: _____

Date: _____

Name of infant: _____

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

Infant #_____   **Experiment #_____**

Infant Perception Laboratory

Family Information Sheet

(All information is strictly confidential)

Infant's Birthdate: _____   Mother's Age:_____ Father's
Age:_____

Mother's Occupation: _____ Father's Occupation:
_____

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

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

Annual Family Income: $10,000-$20,000 $20,000-$35,000 $35,000-$50,000
$50,000-$65,000

                             $65,000-$80,000 $80,000-$95,000   > $95,000

Marital Status: Married   Separated   Divorced   Unmarried/Single
Widowed

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

                     Other_____

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

                     Other_____

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

Infant's Birthweight: _____ lbs _____ozs

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

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

_____   M   F
_____   M   F

_____   M   F
_____   M   F

What is the primary language spoken in your home?
_____

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

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

How did you find out about our study?   Letter   Brochure

SELF-EXPRESSIVENESS IN THE FAMILY QUESTIONNAIRE

This is a questionnaire about expressiveness. To answer the questionnaire, try to think of how frequently you express yourself during each of the following situations with family members. Circle a number on the rating scale that indicates how frequently you express yourself in that situation when it occurs. Thus, if you never or rarely express those feelings, circle a 1, 2, or 3. If you express those feelings with some or moderate frequency, circle a 4, 5, or 6. And if you express those feelings very frequently, circle a 7, 8 or 9.

Some items may be difficult to judge. However, it is important to answer every item. Try to respond quickly and honestly about yourself. There are no right or wrong answers, and we don't believe that any answer is better than another.

```
+----------+----------+----------+----------+----------+----------+----------+----------+
    1          2          3          4          5          6          7          8      9
not at all                              somewhat                   very frequently
                                        frequently
```
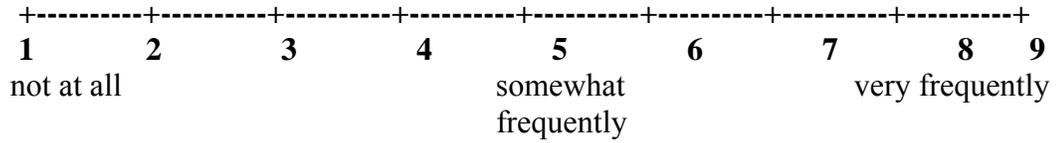
1. Showing forgiveness to someone who broke a favorite _____ possession.

2. Thanking family members for something they have _____ done.

3. Exclaiming over a beautiful _____ day.

4. Showing contempt for another's _____ actions.

5. Expressing dissatisfaction with someone else's _____ behavior.

6. Praising someone for good _____ work.

7. Expressing anger at someone else's _____ carelessness.

8. Sulking over unfair treatment by a family _____ member.

9. Blaming one another for family _____

troubles.

10. Crying   after   an   unpleasant _____
    disagreement.

11. Putting   down   other   people's _____
    interests.

12. Showing   dislike   for _____
    someone.

13. Seeking   approval   for   an _____
    action.

14. Expressing   embarrassment   over   stupid _____
    mistakes.

15. Going to pieces when tension builds _____
    up.

16. Expressing   exhilaration   after   an   unexpected _____
    triumph.

17. Expressing   excitement   over   one's   future _____
    plans.

18. Demonstrating _____
    admiration.

Please rate how frequently you do the following things when you are with your family. Use the scale shown below, and write in the number that fits best for you beside the item.

```
+----------+----------+----------+----------+----------+----------+----------+----------+
1          2          3          4          5          6          7          8    9
not at all                                somewhat                    very frequently
                                          frequently
```

19. Expressing sorrow when a pet _____ dies.

20. Expressing disappointment over something that didn't _____ work out.

21. Telling someone how nice they _____ look.

22. Expressing sympathy for someone's _____ troubles.

23. Expressing deep affection or love for _____ someone.

24. Quarreling with a family _____ member.

25. Crying when a loved one goes _____ away.

26. Spontaneously hugging a family _____ member.

27. Expressing momentary anger over a trivial _____ irritation.

28. Expressing concern for the success of other family _____ members.

29. Apologizing for being _____ late.

30. Offering to do somebody a _____ favor.

31. Snuggling up to a family _____

member.

32. Showing how upset you are after a bad _____
    day.

33. Trying to cheer up someone who is _____
    sad.

34. Telling family members how hurt you _____
    are.

35. Telling family members how happy you _____
    are.

36. Threatening _____
    someone.

37. Criticizing someone for being _____
    late.

38. Expressing gratitude for a _____
    favor.

39. Surprising someone with a little gift or _____
    favor.

40. Saying "I'm sorry" when one realizes one was _____
    wrong.

Thank you for your time!

Appendix F

Positive and Negative Affect Schedule

Read each item and then mark the appropriate answer in the space next to each word. Indicate to what extent you generally feel this way, that is how you feel on the average. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

_____ interested   _____ irritable
_____ distressed   _____ alert
_____ excited   _____ ashamed
_____ upset   _____ inspired
_____ strong   _____ nervous
_____ guilty   _____ determined
_____ scared   _____ attentive
_____ hostile   _____ jittery
_____ enthusiastic   _____ active
_____ proud   _____ afraid

Appendix G

FACIAL AFFECT RATING SHEET

INFANT ID# _____   EXP# _____   RATER _____

Category

	POSITIVE	NEGATIVE
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4
TRIAL _____	1 2 3 4	1 2 3 4

Appendix H

EMOTION CODING SCHEME
(Ratings are based on highest possible level present, regardless of duration or frequency)

Positive Hedonic Tone

Laughter (4)   Vigorous smiles with laughter

Smile (3)   Warm smile accompanied by bright eyes but not laughter

Interest (2)   Fleeting smiles without whole body movement; excitement in body
                      Movements without accompanying warm smiles

None (1)   None of the above (hedonic may be neutral or negative)

Negative Hedonic Tone

Marked (4)   Distress in face. Full-blown cry, accompanied by appropriate
                      Expressions (e.g., screwing up face, closed eyes, maybe tears)

Fuss (3)   Whimpering or fussing with appropriate facial expression.

Frown/protest (2)   Pouting, pre-cry face

None (1)   None of the above (hedonic tone may be neutral or positive)

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EDUCATION:

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Ph.D. in Psychology (anticipated May 2007)
    Advisor: Dr Robin Panneton
    Title of dissertation: "Effects of Vocal and Facial Emotion on Word Recognition in 11-month-old Infants"

M.S. in Psychology May 2005
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    Title of thesis: "Gender of Speaker Influences Infants' Discrimination of Non-Native Phonemes in a Multimodal Context"

Panjab University, India

    B.Sc. in Microbiology (Honors School), July 2000

ADDITIONAL EDUCATION

Bluefield State College, Spring 2002

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TEACHING POSITIONS:

Virginia Tech

Graduate Instructor
- Psychology of Learning, Fall, 2006

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RESEARCH POSITIONS

Graduate Research Assistant
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CHAPTER (Published):

Bhullar, N. (2003). Introduction to states of consciousness. In Lehman, Dula & Finney, ed., Introductory Psychology Recitation Reader. McGraw Hill; 83-85.

Dunsmore, J.D., Noguchi, R.J.P., Garner, P.E., Casey, E.C., & **Bhullar, N**. (2006). Gender-specific linkages of Affective Social Competence with peer relations in pre-school children, Early Education and Development.

RESEARCH PAPERS (Submitted):

Panneton, R., McIlreavy, M.E., & **Bhullar, N.** (2006). Language development: Preverbal development. In M.M. Haith & J.B. Benson (Eds.), Encyclopedia of Infant and Early Childhood Development.

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Bhullar, N. (2006). Functions of Infant-directed Speech: A new perspective.

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POSTER AND PAPER PRESENTATIONS:

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Ostroff, W., Panneton, R., & **Bhullar, N.** (2005). Female face and voice information enhances infants' discrimination of non-native speech contrasts. Paper presented at a symposium at the Society for Research in Child Development, Atlanta, May 2005.

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